A METHODOLOGY
FOR PREDICTING THE PERFORMANCE
OF CONSTRUCTION CONTRACTORS

Gary D. Holt BSc (Hons), MCIOB, MIConstM, MFB

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Abstract

This thesis addresses a fundamental decision problem, encountered by U.K. construction clients faced with a construction contract to assign: the judicious selection of a contractor.

Initially, the inadequacies of current selection practices are confirmed. These findings influence the development of a new selection model, with emphasis on promoting a rationalised, quantitative technique able to identify the potential (project) performance of those contractors evaluated. This approach contrasts with present trends which promote subjectivity and rely heavily upon practitioner experience / judgment.

A nationwide survey of practitioners and client groups identifies discriminating criteria essential to contractor selection, whilst also facilitating the knowledge of their importance (via weighting indices) within the selection process. The multi-attribute analysis (MAA) technique embraces these criteria and is employed for its ability to aid decision making in the presence of multiple, often conflicting objectives, as characterised by *this* 'real life' decision problem.

Within the model contractor's attributes are measured, the resulting scores serving as multiplicands for the aforementioned weighting indices. The aggregate resultant yields a comparison measure. Utility values are also exercised to mirror client preferences and thereby influence optimal choice. The new technique is fully elucidated by worked example with validity being achieved by application to live selection situations. Finally, the potential for any change to existing tendering practice is investigated, via nationwide survey of U.K. construction contractors.

The author has to some extent encompassed building and civil engineering, but the emphasis of this work is on the building sector.

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I acknowledge the countless client groups and industry practitioners who contributed and collaborated throughout. Such contribution called for a high degree of commitment at a time of adverse economic / market pressures. Thank you, without such input the research would not have been possible.

A very special thank you is extended to my research supervisors; Dr. Paul O. Olomolaiye, Ms. Pauline Corbett and Professor Frank C. Harris. Their combined enthusiasm, guidance and direction proved an inspiration throughout.

Finally, thank you to my family who gave up so much in order to make this possible.

I recognise and promote the role of women in the construction sector and therefore ask readers of this thesis to perceive the use of the masculine pronoun as referring equally to both sexes!

Dedicated to Lynn, Mark and Rod

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CHAPTER 1

INTRODUCTION

1.0. NATURE OF THE RESEARCH

This research focuses upon a characteristic of the construction industry -the selection of construction contractors[1]. This characteristic is a function of the diverse and fragmented nature of the industrys' clientele with their infinite range of needs, and is magnified, by an equally multitudinous array of construction companies sustained by, and placating, this client demand. Normally, this interface of supply and demand results in a contractor selection exercise. Ideally, such an exercise should enable the client to *confidently* entrust in the chosen contractor, responsibility to *satisfactorily* execute the project.

Unfortunately, this is not always the case. Contractor's essential instinct to survive in an increasingly competitive environment, makes it inevitable that sometimes corners will be cut and standards neglected. A further feature of the industry is the intense competition caused by a large number of firms competing in a decreasing market, -a market characterised by low profit margins and high failure rates (Humphries, 1994).

The undesirable aspects of unscrupulous firms and low profitability, are often accentuated by client's apparent inability to resist other than the 'cheapest' solution, that is, the lowest bid. Notwithstanding that two fundamental factors exist in contractor selection ie., price and suitability, price normally dominates the process at times to the exclusion of suitability (Hartman, 1993). Consequently, the products of

[1] In the context of this thesis the term *contractor* refers to the main contractor contractually employed by the construction client to execute the project. Any firms subsequently employed by the main contractor in pursuit of that objective will be referred to as *sub-contractors, specialist sub-contractors* or *domestic sub-contractors.*

construction often fall short of expected standards in terms of time (contract overruns), cost (failure to meet budget) and quality (below client expectations). Furthermore, the pressure on profit margins brings instability to the industry as evidenced by a high number of contractor insolvencies (cf. C.S.O., 1992; 1993; 1994).

Over recent years many clients have attempted to redress this situation. There has emerged a trend away from the 'traditional' Architect led procurement route towards more 'modern' forms of procurement such as management contracting and design / build. Generally, clients believe that these alternative methods apportion a greater degree of the risk associated with any construction venture onto the contractor and that therefore, financial risk to the client from choosing the *wrong* contractor is reduced (Holt et al., 1993A). This trend only obscures the problem -a contractor selection exercise must be performed regardless of procurement form, or tendering method employed. Furthermore, off-loading responsibility and risk onto contractors is not in tune with generating the non-adversarial client relationships that the industry is now purporting to strive for (Latham, 1994).

The above not only underlines the importance of contractor selection but also the potential scope of the research area. For example, one might consider method of procurement (traditional/package deal), tendering arrangement (open, select, two stage, serial), tendering documentation (BOQ's, drawings, specification), contract form (JCT, clients' own, contractors own) etc. Since each of these variants could be worthy of a research in their own right, it was necessary to introduce parameters.

This work honed in on the more popular traditionally procured, single stage selection, lump sum contract option, but the developed methodology could be equally applied in alternative selection scenarios. For instance; Management Contractors could adopt the process to the selection of specialist or trade contractor packages. Indeed, a streamlined version could perhaps be used by contractors themselves to select sub-contractors. The work has to some extent encompassed building *and* civil engineering, but emphasis is on the building sector.

1.1. AIMS AND OBJECTIVES OF THE RESEARCH

The principle aim was to develop a methodology for selecting construction contractors specifically, in terms of implementing a comprehensive evaluation and subsequently identifying their (project) performance potential. This would then serve as a selection decision support system for construction owners[2].

This primary aim embraced the following sub-objectives;

a) to review the current situation regarding tendering practice within the UK construction industry;
b) to review previous studies of contractor selection both in the UK and abroad;
c) to offer a rationalised alternative to existing selection practice;
d) to develop a method suitable for universal adoption by the industry;
e) to encompass within the new technique the *entire* selection process from initial prequalification of contractors through to final selection choice;
f) to discriminate, by evaluating contractor performance potential for meeting client requirements: time, cost and quality;
g) to furnish the construction owner with a quantitative, numeric, comparison measure for each contractor under review, at each of the stages in (e) above;
h) to ultimately identify optimum choice, based on a combination of the said evaluation exercise and consideration of tender sum submitted, for each contractor invited to tender;
i) to have developed a technique suitable for adaptation to modern day information technology; and
j) to investigate trends, central tendency and statistical association within

[2] In this context an owner is defined as a person(s) with a construction contract to assign whether that be the client or a third party conducting a selection exercise on the clients' behalf.

contractor's attributes particularly, in respect of 'good' / 'not-so-good' contractors and, 'high' / 'low' bidders.

1.2. RESEARCH METHODOLOGY EMPLOYED

The research began with an extensive literature search. This exercise firstly confirmed the weaknesses inherent within present day selection methods and secondly, identified discriminating criteria that commentators considered prudent for application to firms during selection. A subsequent nationwide survey of selection practitioners and client groups, reinforced the existence of the above weaknesses and consolidated the knowledge of *essential* selection criteria and, their relevant levels of importance within the selection process.

A review of modelling techniques confirmed that multi attribute analysis (MAA) combined with the concept of utility values, were ideally suited to this decision task. Theoretical application of the subsequently developed MAA model verified its ability to discriminate between 'good' and 'not-so-good' firms. It was also shown that the utility concept further amplified those contractors, who were able to 'score' well in those selection criteria perceived as important (by a client) to a particular project.

Application of the model to real life selection exercises confirmed the validity of the technique, particularly, ability of the model to highlight most salient contractor characteristics. Statistical analysis of model outputs during this phase also determined bench marks, regarding contractor distinctions in terms of 'good' / 'not so good' firms and 'high' / 'low' bidders.

Finally, a national survey of UK construction contractors served as a conclusion to the research programme. This yielded *inter-alia* opinion of tendering and contractual arrangements within the construction sector, along with contractor perception of the Latham Review. It was coincidental that during the lifetime of this research, the government conducted a review of the industry -making procurement recommendations that mirrored those of this research, made some eighteen months beforehand. The survey also offered contractor feedback on some of the prominent characteristics of the evaluation / selection method developed herein.

1.3. ACHIEVEMENTS

This work successfully spanned two research grants: i) "Development of a methodology for predicting the performance of construction contractors and consultants" funded by the Leverhulme Trust and: ii) "Validation of a methodology for predicting the performance of construction contractors" funded by the Engineering and Physical Sciences Research Council.

Twelve technical papers were produced directly as a result of this research programme. Titles follow - complete reference is given in the *references* section.

Tendering practice - exploring alternatives (1993).
A conceptual alternative to current tendering practice (1993).
Factors influencing UK construction clients choice of contractor (1993).
Evaluating performance potential in the selection of construction contractors (1994).
Evaluating prequalification criteria in contractor selection (1994).
Incorporating project specific criteria and client utility, into the evaluation of construction tenderers (1994).
A generic approach to the selection of construction contractors (1994).
A review of contractor selection practices in the U.K. construction industry (1995).
Applying multi-attribute analysis to contractor selection decisions (1995).
A case study approach to investigation of contractor attributes (1995).
Application of an alternative contractor selection model (1995).
Tendering procedures, contractual arrangements and Latham: the contractors view (1995).

All clients who collaborated in this study have reviewed their own selection methods based on feedback from the research. Such reviews have resulted in those clients updating their selection procedures -all have benefited to some extent.

One client who was particularly involved with the work, has adopted the new method in its entirety -see Appendix A.

A summary of the research findings (at that time) were presented to and acknowledged by the Latham Review who were conducting a joint government / industry review of procurement and contractual arrangements in the UK construction industry during 1993 / 4 -see Appendix B.

Findings pertaining to qualification and attribute evaluation were presented to the Latham Review Implementation Forum working group 5 (who's objective was to develop a standard qualification form for the selection of contractors desirous of public sector work) -see Appendix C.

Dissemination of these research findings has generated tremendous interest confirming that the subject area required investigation. The potential of this sphere of work ie., in the field of construction procurement, has been recognised by others.

Since *this* research began in 1992, other research programmes have commenced along parallel routes but on a different theme. For example, at Salford University (SERC funding) and at Birmingham University (Private sector funding).

The writer believes that this interest will snowball for many years to come.

1.4. ORGANISATION OF THE THESIS

1.4.1. Chapter 2: Chronological development of the contractor selection (tendering) process

Here the reader is introduced to the research theme. Background to present day selection (tendering) practices is investigated, in particular, the gradual shift in attitudes from 'open' towards 'selective' methods.

The former mode of free competition was considered by owners a necessary prerequisite to acquiring competitive bids, but the abortive costs involved proved burdensome on the industry. It's replacement reduced the volume of resources wasted on unsuccessful bids, but brought with it a misplaced general belief, that the lowest bid could be confidently accepted from any prequalified contractor. This is not so, low bids are often common to 'unscrupulous' or financially unstable firms. Regarding the latter, it is the owner that ultimately pays for contractor business failure (Hartman, 1993).

An overview of procurement trends at the turn of the decade shows that select competitive tendering based on bill(s) of quantities and drawings are the favoured combination for most selection exercises.

1.4.2. Chapter 3: A critique of present day selection methods

This chapter lends intense weight to justification of the research programme, by identifying inherent weaknesses of current selection methods. It is also confirmed, that notwithstanding orthodox codes of procedure (purporting to offer standard selection guidelines for both civil engineering and building sectors), the amount of variation inherent within the industry, is considerable. Such variance, in the shape of home grown, fragmented, ad-hoc selection measures is astounding, particularly so, when one considers that selecting a contractor is one of the most important decisions the client has to make.

Many clients utilise select[3] lists but these often become outdated, that is, composed of firms at whom no prequalification *review* has been levelled (in many instances for several months). The writer has witnessed extreme cases where no review has been implemented for up to five years.

Possible adverse effects for the owner of such variance and poor practice are investigated. Finally, the means of redressing these issues is discussed, yielding initial indication of the requisite requirements of an alternative selection technique.

1.4.3. Chapter 4: The essence of selection - discriminating criteria

This chapter underlines the root of this selection task -defining which discriminating criteria to apply when having to choose between alternatives. The beginning of the chapter investigates those criteria (exposed via the literature survey) that are considered as important by authors and commentators. These observations then serve as a basis for initiating a nationwide survey, the results of which are presented in the second part of the chapter. By analysing the survey data, a weighting index was established for each selection criterion thus enabling incorporation of each into the model. The survey also reinforced the failings of current practice earlier identified in chapter three.

1.4.4. Chapter 5: Development of an alternative contractor selection model

Initially, the selection task is confirmed as being essentially a decision problem. An elementary overview of modelling techniques in respect of such problems is then presented.

Broader elucidation of multi attribute (decision) analysis and utility theory are given,

[3] Also known as standing, approved, tender and rotational lists.

with most specific emphasis in the contractor selection context. A logical, stepwise sequence of functions necessary to effectively select a contractor is derived. These functions, when consolidated with the mechanisms required to redress the weaknesses identified in chapter three, jointly serve as the rationale for a new selection model -who's evolvement is fully described and mathematically presented.

1.4.5. Chapter 6: Evaluating contractor attributes

This is an in-depth literature search and investigation which studied each criterion identified from chapter four. The most pragmatic and quantitative methods of evaluating contractors for each criterion are derived.

The results of these attribute evaluations must be incorporated into the algorithmic model. Therefore, the next task was to establish a method for converting a contractors' attribute scores (in terms of natural units: descriptive, ordinal, binary etc.), into commensurable values on an interval scale. This is also fully described.

1.4.6. Chapter 7: A worked example of the selection model

This chapter brings together the theory of the models' development. A fully worked, numerical example of the new technique is presented in an hypothetical selection scenario, from prequalification of contractors to final selection choice. It is also demonstrated how a discounted cash flow analysis of bids may be incorporated into the model to account for the time value of capital. The chapter concludes by highlighting how it is not necessarily the lowest bidder that should be awarded a contract, but rather the contractor exhibiting the best all round performance potential when a broad cocktail of selection criteria *and* tender sum are considered.

1.4.7. Chapter 8: Validation of the model

This chapter explains case study applications of the model. Model output is observed and compared to client 'scores' for contractors (where the client has past experience with the companies), along with project performance scores (based on actual performance). The various components of model output are statistically analysed, to yield trends and levels of association within contractor characteristics.

These findings are segregated into good / not so good contractors and, high / low bidders with the conclusion that high bidders tend to achieve higher attribute scores.

Finally, validity of the model in terms of ability to classify good and not so good contractors, is confirmed by applying the statistical technique of cluster analysis.

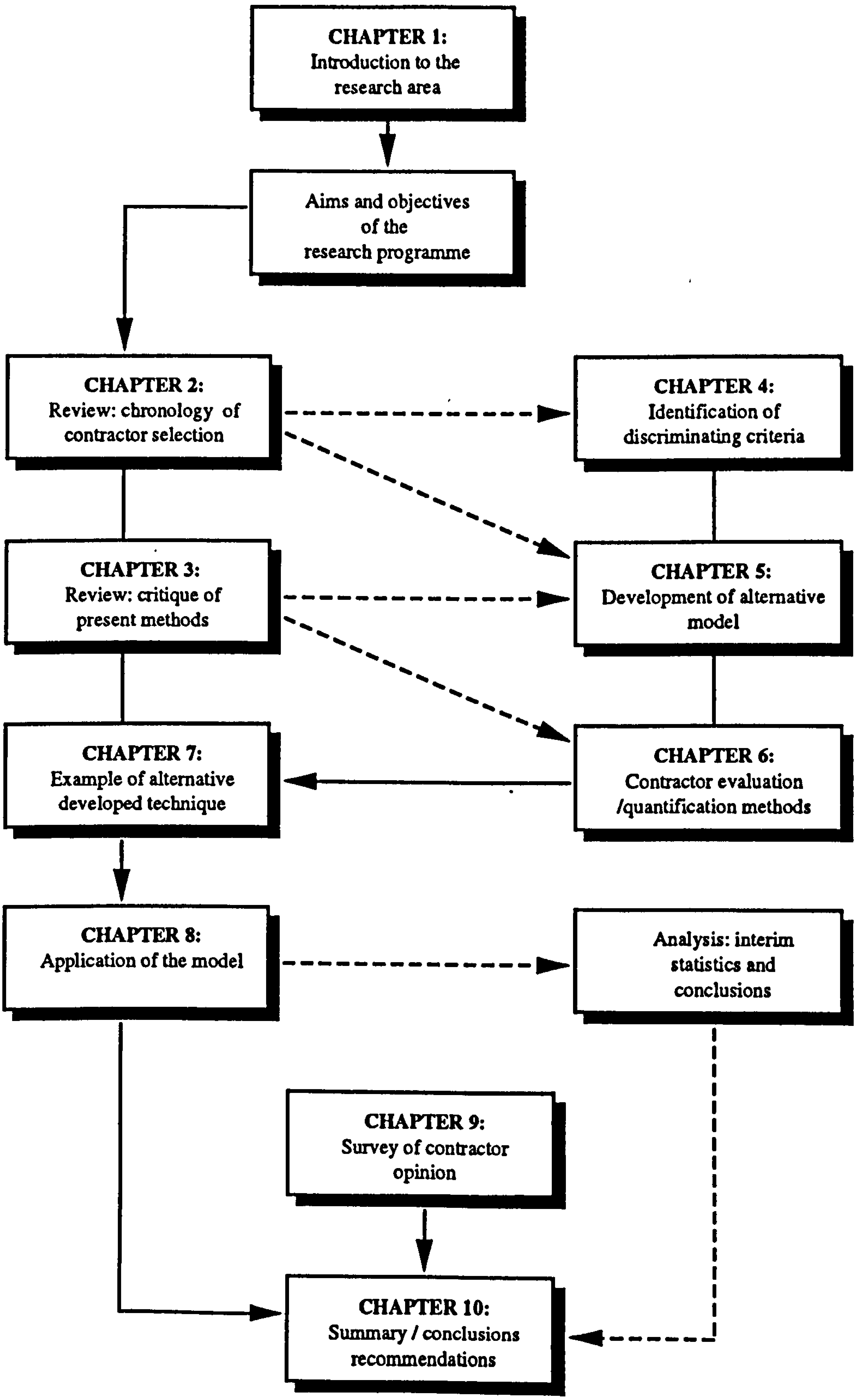
1.4.8. Chapter 9: The contractors' view

As a conclusion to the research a national survey of UK contractors is presented. Firstly, this serves as a contrast in that the fundamental theme of this work looked at selection from the client's standpoint. Secondly, an up to date overview of current procurement trends are established. Finally, based on *contractor* opinion, future scope for changes to present day practice are discussed.

1.4.9. Chapter 10: Conclusions, recommendations and further research

The fundamental issues of the research are highlighted and conclusions drawn, along with recommendations for future research.

Figure 1.1.
Flow diagram - organisation of the thesis



CHAPTER 2

CHRONOLOGICAL DEVELOPMENT OF THE CONTRACTOR SELECTION (TENDERING) PROCESS

2.0. INTRODUCTION

This chapter provides an overview of the development of the U.K. construction tendering process; in particular, since the report of the Simon Committee (1944). Simon were instrumental in bringing about a change in attitudes towards hitherto favoured 'open' tendering and encouraged a shift towards more 'selective' and negotiable methods. The chapter includes discussion regarding Codes of tendering Procedure along with 'more general' guidance documents. From these are abstracted the most salient points regarding present day contractor prequalification and selection practice.

Finally, the most eminent selection (ie., tendering) methods in use are described, along with their respective advantages and disadvantages. In short, the chapter provides the reader with an introduction -a background to the environment within which the selection of contractors takes place.

2.1. SETTING THE SCENE

In procuring a construction product, it is inevitable that a client will at some time need to select a contractor in whom can be confidently entrusted the project, to be completed on time, within budget and to the desired quality. This is one of the most important decisions faced by the client (Odusote, 1990; Russell et al, 1992).

Elementary economics has demonstrated the concepts of supply / demand and free competition / price levels. These same principles are fundamental to the philosophy of competitive tendering, that is, a number of contractors competing for contract award in genuine competition, should achieve the best value for money for the client (Smith, 1986). Hence, competitive tendering has been employed within the construction industry as the predominant means of selecting contractors for hundreds of years (Burrows, 1981).

Early modes of tendering essentially involved intermittent pre-contract communication between the architect and the builder. However, towards the end of the 18th Century the role of architect's became moulded into more or less its present form, at which time they were perceived as both professional independent construction designers and, the 'leaders' of project coalitions[1]. 'Traditional' procurement was established! At about this time -after the seeds of industrialisation had taken root and the expansion of towns was under way, methods employed in the placing of building contracts played a leading role in the evolution of tendering practice.

This period influenced both architects (eg., preparation of pre-contract documents / evaluation of tenders) *and* builders (eg., manner of estimating costs, the time allowed for and, method of tender submission).

Further formalisation followed, indeed, was inevitable during the early 19th Century, with the introduction of the Bill of Quantities (BOQ). Henceforth, the BOQ became the means of providing a number of different contractors with a common basis, upon which to compile their bids (Skitmore, 1989; Franks, 1990).

Up until the 1950's the majority of construction contracts were typically 'designer

[1] In this context the project coalition shall be those parties directly involved with the design & production of the project. For example, Architect, Quantity surveyor, Consultant, Contractor, Client etc. Obviously the members of a coalition are a direct function of procurement form utilised.

led' ie., traditionally procured. Selection of contractor and assignment of contract was most often achieved via *open tendering*. However, as will be shown in the following section, since that time, the construction industry has witnessed significant changes in the way contracts are procured and managed (Brook, 1993).

2.2. EVOLUTION OF TENDERING PRACTICE -THE LAST 50 YEARS

2.2.1. The Simon Committee report (1944)

Throughout the inter-world war years the U.K. building industry had produced four million residential dwellings and by 1939 was employing in excess of one million workers. Towards the end of the Second World War the Government had even greater aspirations for the industry. They instructed the Simon Committee;

"To examine the whole question of the placing and management of building contracts; to consider how far existing practices are suitable and to make recommendations to secure that building organisation shall be so improved as to provide the best possible service to the nation" (Simon, 1944).

This request for a critique of the industry was predominantly instigated by the effects of war on the infrastructure of the country. They explained;

"(when the war is over) there will have been no building for peace purposes for more than five years, there will be bomb damage to be made good, a mass of deferred repairs and maintenance....demand for schools....civic and industrial buildings...and finally, continuing demand for houses."

In order to meet this demand, they pronounced a doubling of inter-world-war output. Four million new homes were to be built within ten years of the war coming to an end and, the number of workers in the industry was to be increased to one and a quarter million within three or four years. This ambition represented substantial increases in productivity and output.

Scope of the final report was far reaching. The committee were quite damning towards hitherto use of *open tendering* citing that such an indiscriminate method allowed 'good' and 'bad' builders to compete on equal terms. Subsequently this was tempting unscrupulous operators to tender ridiculously low bids (cf. *suicidal bids* Merna & Smith, 1990). Such bids could only leave contractors a substantial loss if the work were carried out to tender specification, implying that contractors were having to cut corners or make up losses by other means (claims!). Furthermore, albeit open tendering often led to such unscrupulous builders being awarded construction contracts, the method was conducive to the purchasing of inferior materials and, a speeding up of the work -making good craftsmanship impossible. "By every kind of device, contractors seek to reduce costs and make claims for extra's in every possible way, legitimate or illegitimate" (Simon, 1944).

In the alternative, *selective tendering* was cited as a means of ensuring only competent companies bid for an award. They went on; "where firms who work on the same level as regards quality of work tender one against the other, competition should produce a fair competitive price and..enable contractors to give a satisfactory job at a reasonable remuneration."

The report also highlighted the unnecessary burden of time, effort and expense 'foisted' upon the industry in the preparation of bids, when the number of contractors taking part was not restricted. It recommended that competitive tenders should in all cases be called from only a limited number of firms -carefully selected as being capable of and, likely to do the work to the standard required.

It further advocated that free competition was desirous via the advertising of building work. However, advertisements previously placed for the purpose of *inviting tenders* from builders, should now invite firms specifically for *permission to tender* ie., invitation to prequalify. The advent of the 'standing' / 'approved' / 'select' list was commenced and subsequently in the committees' view, formed a satisfactory basis for selecting contractors to tender.

With specific emphasis on local authorities, it was confirmed that but for exceptional circumstances (and in accordance with the Local Government Act 1933), the lowest bid *must* be accepted from whomsoever it was received.

This latter point was a major failing of Simon Committee's suggested practice ie., the erroneous assumption that once contractors satisfy prequalification then the lowest bid may be confidently accepted! Such confidence may only apply *if* the prequalification exercise was as comprehensive as it needed to be *and* properly executed. These points are expanded upon in the following chapter. Nonetheless, it is generally accepted that the Simon Committee were the initiator of the subsequent shift away from open tendering methods.

Simon would also be credited with promoting negotiated procurement -which encourages the contractor to become involved with the project earlier eg., during the design stage. It was suggested that the confidence thus shown by the client in the builder would lead to reciprocation and the builder paying special attention to the job. (Presently, the construction industry is experiencing a growth of 'package deal' procurement which facilitates such early contractor involvement, a prime example being design and build).

2.2.2. The Banwell Report (1964)

The Simon Committee report was followed up two decades later by the now somewhat notorious Banwell investigation;

Sir Harold Emerson was asked by Geoffrey Rippon the then Minister of Public Building and Works, to consider the practices adopted for the placing and management of building and civil engineering work and, to make recommendations with a view to promoting efficiency and economy within the industry.

Subsequent findings (Emerson, 1962) led to the formation of the Banwell Committee (1964) which recommended that several changes be introduced to contractual practice. The most pertinent conclusions of the Banwell report with specific reference to contractor selection included the following;

a) the need to form an integrated team (project coalition) at the outset -because of the increasing complexity of projects;
b) the preference for selective tendering over open methods. Impediments to the former should be removed and rules governing selective methods, should be drawn up for local authority guidance;
c) where appropriate, 'unorthodox' methods of appointing the contractor (eg., negotiation) had advantages which should not be overlooked through adherence to outmoded procedures;
d) further, that negotiated contracts need not be exclusive to the private sector. Such methods of procurement should be examined for the solutions they can offer, rather than their orthodoxy;
e) serial tenders offered greater possibility for continuity of employment along with the development of experienced production teams. This encouraged the bringing together of those who had similar work in prospect.

It is noticeable that Banwell reinforced many comments previously raised by the Simon Committee.

Banwell also confirmed, that many clients were convinced that a building project could only be secured at the lowest possible cost when each job was individually advertised and, contractors were able to submit their bid in free competition (without any enquiry as to their competence to do the work). Furthermore, that clients believed suspicion of favouritism was only removed by way of such free competition ie., no firm should be 'eliminated' until all tenders were received, in order to give up and coming firms the ability to tender for contracts. In short, no firm wishing to tender should be prevented from doing so.

These perceptions explain to some extent the reasons for open tendering maintaining favour but as will become apparent below, the method was about to lose it's popularity.

2.2.3. The Building Economic Development Committee (1967)

The Building Economic Development Committee (B.E.D.C.) further confirmed the two fundamental drawbacks of open tendering, these being low prices resulting from indiscriminate methods which tend to give rise to bad building and, the resources wasted on compilation of bids when too many firms tender for the same job.

They also set about discovering how much 'other methods' of tendering were being used at that time and to what extent movement had occurred away from open tendering since Banwell.

Because very few private sector clients were now employing the open tendering option, the B.E.D.C. confined their enquiries to the public sector for the period 1964-6. Their enquiry looked specifically at the following factions of construction; Local Authority housing, Schools & Universities, Hospitals, Central Government contracts and, Nationalised industries.

A summary of their findings is given because they furnish an excellent overview of tendering practice and trends in England and Wales at around 1966.

2.2.3.1. Local Authority Housing

The Ministry of Housing and Local Government had issued a circular to local authorities in 1964 urging greater use of selective tendering. A tendency to this effect was discovered in the three year period investigated. Nonetheless, forty percent of all schemes accounting for twenty percent of all dwellings, were still let by open tender -see Table 2.1. Their conclusion was that the Ministry of Housing and local government should issue a further circular to local authorities urging greater use of selective tendering in particular, for smaller housing schemes.

Table 2.1.
Local authority housing contractor appointment percentages

Tendering Method	*Number of Schemes*			*Number of Dwellings*		
	June quarter			**June quarter**		
	1964	1965	1966	1964	1965	1966
Open	49.2	43.2	39.3	31.4	28.6	20.2
Selective	20.0	20.4	24.2	22.6	17.7	30.3
Negotiated	23.3	27.8	27.4	29.0	40.7	35.2
Package deal	7.5	8.6	9.0	17.0	13.0	14.3
	100%	100%	100%	100%	100%	100%

Source: NEDO 1967.

2.2.3.2. Schools

The survey found that for the period there had been a sharp decline in the total *value* of schemes awarded by open tender, although the *number* of schemes had increased slightly. This indicated that open tendering was still widely used for small projects hence, a reduction of such was urged.

2.2.3.3. Universities

Here it was found that open methods were not used other than for very small contracts. For larger contracts, appointment by negotiation was sometimes employed but this normally required Department of Education and Science approval. The B.E.D.C. contended that this undue caution impeded greater use of negotiation and recommended that the Department of Education and Science should be given greater freedom to approve appointment of contractors by 'unorthodox' methods.

2.2.3.4. Hospitals

The Ministry of Health at that time were unable to provide numerical data but stated that it favoured selective tendering and, that it had recommended hospital boards to obtain bids from about six firms for most building contracts. However, the BEDC found that as many as ten or twelve firms were competing for awards -particularly specialist works. Subsequently, hospital boards were urged to adhere more strictly to the *size* of select lists as recommended by the Ministry of Health.

2.2.3.5. Central Government Contracts

It was discovered that here open tendering was not in use. The value of work let in this sector (UK and abroad 1964-5) was approximately £120 million -nearly all via selective tendering, with the remainder being made up by various forms of negotiation.

Finally, the report confirmed that (the then) nationalised industries were not at all exercising the open tendering option.

2.2.4. Tendering trends (1987)

A more recent analysis of tendering methods and procedure was conducted by Bresnen et al. (1987), who found a great deal of variation in the methods employed and basis upon which tendering was done -see Table 2.2.

Table 2.2.
Tendering trends -1987

Method of tendering		Basis of tendering	
Open competitive tender	7%	Bill, Spec. & drawings	56%
Select competitive tender	63%	Spec. & drawings only	22%
Negotiation	26%	Approximate bills	12%
Two stage tender	4%	Other	9%
Serial or continuity	nil		
	100%		100%

Adapted from Bresnen et. al. 1987.

The Table confirms that competitive, selective methods held greatest prominence. Nonetheless, a quarter of those surveyed utilised some form of negotiation. This may seem surprising in view of negotiations' potential to be abused (ie., lack of accountability on the part of the contractor) but this statistic does correlate with the earlier findings of (what was then) the I.O.B; "Competition is useful but not necessarily essential as a means of achieving value for money. Evidence shows that contracts let by open or select single stage competition appear less successful than those let by other means. Negotiated and two stage tender work appear more successful and there is less divergence in comparing final contract values and tender values, than by other means" (I.O.B., 1979).

It is also interesting to note from Table 2.2. that open methods have all but disappeared. The following points are abstracted from Bresnen et al. to summarise their findings;

There was a clear trend in the use of different types of tendering system according to type of project / type of client. Generally, what could be described as 'flexible' approaches (negotiation coupled with the use of specification and drawings) were more commonly found in private sector new build projects undertaken by clients who did not have an in-house project team. What could alternatively be described as 'structured' approaches (competition coupled with full bills or bills of approximate quantities) were found more commonplace in the public sector.

Concerning the *type of work*, public works (especially housing) involved more 'structured' approaches whilst industrial and commercial projects utilised flexible approaches. New build projects involved more negotiation whilst refurbishment projects involved more competition. Regarding *types of client*, the public sector used more 'structured' and the private sector more 'flexible' approaches.

Two broad approaches of selecting the contractor to tender or negotiate were identified;

a) a 'neutral' approach using the EEC method (see later) and rotated lists[2] for competitive tendering;
b) what could be labelled a 'proactive' approach using single firm selection for negotiation, or recommended shortlists by either the architect, project manager or client.

[2] Rotated lists involve inviting (the required number of) contractors to tender from the top of the select list. After tendering, these contractors are subsequently placed at the bottom of the list. Those now holding the top slots are invited to tender next time around, and so on.

Not surprisingly given public accountability, public clients used a more 'neutral' approach and private clients a more 'proactive' approach. Finally, the results on performance were mixed. Negotiation produced the best time performance but the worst cost performance; full bills of quantities produced the worst time performance and open competition the best cost performance. Consequently, public clients appeared to achieve less costly projects but suffer time overruns, whereas private clients got the job finished on time using more flexible methods, but at a cost.

2.2.5. The influence of the single European market (1992)

Until recent times, British Local Authorities (LA's) were able to exercise free choice whether to execute public works and services with their own directly employed personnel or, to fulfil these responsibilities via award of contracts to the private sector. There has been a gradual erosion of this freedom of choice during the 1980's. Firstly in public works and later in services, a new regime known as Compulsory Competitive Tendering (CCT) was introduced by the Government (c.f. Simpson, 1995). This meant that LA's had to first expose major functions to competition ie., LA Direct Labour Organisations now had to compete with independent contractors for the right to provide those services.

With the formalisation of the Internal Market in Europe in 1992, awareness has grown amongst LA's and the markets' effects are still being digested. The number of tenders submitted by French, Spanish and Dutch contractors as a consequence of CCT, has provided an indication of what the 'single market' means in practice. All the major European contractors have now exhibited a presence in the UK -seizing the opportunity provided by the property slump at the turn of the 90's and the consequent low Stock Market value of UK construction firms, to buy into British construction companies (Diggings 1991).

Conversely, British firms have largely withdrawn from international contracting and have so far found the European market a difficult nut to crack (ibid).

Practically every LA contract of any magnitude is subject to complex European procurement rules and procedures (Directives) emanating from Brussels. The Directives apply to regional / local authorities and with very few exceptions, apply to all types of public works contracts. They come into effect when the value of a contract is above the relevant threshold. As at January 1990 those thresholds were;

a) works:	ECU* 5M	(£3.31M)	
b) supplies:	ECU* 200K	(£132.4K)	* *European Currency Unit*

It is worth pointing out, that the Directives do not intend abolish separate national procedures for the award of public contracts, but rather attempt to co-ordinate them. For this purpose, in the 'European' context all national procedures are categorised as follows;

a) *open procedures*; these being national procedures whereby all interested contractors may submit tenders (traditionally open tendering);
b) *restricted procedures*; national procedures whereby only those contractors invited by the contracting authority may submit tenders (traditionally selective tendering);
c) *negotiated procedures*; national procedures whereby contracting authorities consult companies of their choice and negotiate with one or more of them the terms of the contract.

According to the European common advertising rules, authorities must make their intention to award a contract known, by means of a notice sent for publication in the 'Official Journal of The European Communities'.

In short, the European Directives encourage broader competition associated with the placing of public sector contracts. There is a subsequent need for UK construction contractors to increase their awareness of the single European market in order to maintain a competitive edge and hence, fair share of an ever widening market in the face of increased competition.

2.2.6. The Latham review (1994)

In July 1993, construction minister Tony Baldry launched a twelve month, £250,000 review of the construction industry. The *interim* findings of the review were published by Sir Michael Latham in January 1994 (Latham, 1993; Building, 1994). In addition to giving a most recent analysis of procurement trends (see Table 2.3.), the interim report verified specific failings of tendering practice and contractor selection, as previously indicated by Holt et al. (1993A; 1993B).

Table 2.3.
Analysis of procurement trends -1992

Procurement method	*Percentage of contracts by value*				
	1984	1985	1987	1989	1991
Lump sum -Firm B.O.Q.	58.7	59.2	52.0	52.2	48.2
Lump sum -approximate B.O.Q.	6.6	5.4	3.4	3.5	1.2
Lump sum -specification & drawings	13.1	10.2	17.7	10.2	8.3
Prime cost plus fixed fee	4.4	2.6	5.1	1.1	0.1
Design and build	5.0	8.0	12.1	10.8	14.7
Management contract	12.0	14.4	9.4	14.9	7.8
Construction management	0	0	0	6.8	19.3
Totals	100%	100%	100%	100%	100%

After Latham (1993)

Latham (1993) advocated the use of 'responsible' prequalification systems to ensure that all firms invited to tender were equally capable of doing the work satisfactorily. Further, greater standardisation of prequalification procedures and documentation was recommended. Perhaps the most important proposal for change was that clients should base their choice of contractor (and consultant) on a 'value for money' basis with proper weighting of selection criteria for skill, experience and previous performance, rather than automatically accepting the lowest tender. This underlines the fundamental premise upon which this research is based.

Regarding prequalification and select lists the *final report* (Latham, 1994) recommended that;

a) the Department of the Environment (DOE) should rationalise procedure by preparing a single qualification document, for prequalification of all contractors wishing to tender for public sector work;
b) such 'approved' contractors should be held on a central list maintained by the DOE. Only approved contractors may be employed by Government departments / agencies;
c) a 'star' system be introduced -relative to contractor performance.

The writer contends that standardisation via a single prequalification document is desirable (see *lack of a universal approach* chapter 3). However, whether one central agency could adequately take account of regional variation / regional interests might be prone to question. With respect to tendering procedure, Latham proposed that;

d) clients adhere to National Joint Consultative Committee codes of procedure (NJCC, various) regarding the number of firms invited to tender
e) that open tendering should not be used.

Finally, where design and build procurement is employed then it was advocated that;

f) not more than three firms should be invited to tender;
g) that a two stage selection procedure should be used for complex projects, with a maximum of five firms approached during stage one and, a maximum of two shortlisted for the second stage.

2.3. AN OUTLINE OF PRESENT PRACTICE -BY CONSTRUCTION SECTOR

2.3.1. The Building Sector

Since Banwell to date, selection practice within the *building* sector has been moulded in the main by the National Joint Consultative Committee for building (N.J.C.C.). The N.J.C.C. consists of: The Royal Institute of British Architects, The Royal Institution of Chartered Surveyors, The Association of Consulting Engineers, The Building Employers Confederation, the Federation of Building Specialist Contractors and The Confederation of Associations of Specialist Engineering Contractors. Established in 1954, they identify their constitution as follows; "The N.J.C.C. has always firmly believed that the honourable use of agreed standard procurement and management methods is central to the overall interest of all participants in the building industry". In an attempt to achieve this ambition the N.J.C.C. has produced several Codes of Procedure, these Codes being complimented by guidance and procedural notes (N.J.C.C., various).

As indicated earlier, the last two and a half decades have witnessed a prominence of 'selective' methods -several variations of which are possible. However, two basic forms have been in existence and promoted by the N.J.C.C. namely; single stage selective tendering and two stage selective tendering (full description and the relative merits / demerits of each are discussed under section 2.4. later).

2.3.2. The Civil Engineering Sector

The dominant contractor selection guide here is that produced by the I.C.E. Conditions of Contract Standing Joint Committee: *Guidance on the preparation, submission and consideration of tenders for civil engineering contracts* (I.C.E., 1980). This document is a guide to good practice for civil engineering contracts, although much of it may be applicable for other types of engineering works (ibid).

The guide highlights the case for adopting selective tendering vis-a-vis open methods, the arguments for which have been discussed earlier.

Furthermore, as within the building sector prequalification for the purpose of establishing an approved or select list is recommended. The I.C.E. suggest that the amount of information requested from contractors to achieve this objective should "reflect the technical content of the works" and that; "the factors considered should be assessed under three headings: contractor's technical and organisational ability; general experience and performance record."

Regarding the *number* of firms invited to tender the document recommends that there should be no less than four and no more than eight. As a 'rule of thumb' the larger the contract then the fewer number of bids should be invited. This is obviously designed to minimise wastage of resources.

By their very nature, civil engineering works provide an ideal opportunity for contractors to submit qualified tenders. Potential qualifications are diverse but typically include such things as; part alternative design, alternative methods statements, suggested planning / programming or alternative material schedules. Therefore, the evaluation of submissions must take into account qualifications and bring all tenders onto a common monetary base. Once this (sometimes difficult task) is achieved, final selection is basically performed on price. However, the section dealing with tender adjudication does state; "Do not necessarily select the lowest tender if the Employers' interests might be better met by another contractor, when account is taken of proposed construction methods, organisation and the likely financial out-turn of the project."

2.3.3. International construction works

Albeit this research is concerned with UK tendering practice, the document produced by the Federation Internationale Des Ingeniers Counsels (F.I.D.I.C., 1982); *Procedure for obtaining and evaluating tenders for (international) civil engineering contracts* has been included. This is because F.I.D.I.C. consider their recommendations as suitable for any acceptable contract form and, because the procedural evaluation and selection process commended is quite comprehensive and complimentary to this text. Furthermore, those UK contractors working abroad very often have to conform to F.I.D.I.C. selection procedures.

Paragraph two of the introduction to the document is quoted below, as it encapsulates the fundamental theme of this chapter and shows the emphasis that FIDIC attach to the prequalification of contractors;

"Experience has shown that prequalification is desirable since it enables the employer to establish the competence of companies subsequently invited to bid. It also ensures that enquiries are addressed to leading companies who would not necessarily participate in open bidding, since they do not consider this (open methods) to permit proper competition. Additionally, prequalification has the effect of reducing the inflationary effect which must arise, where companies incur unproductive expense in submitting a large number of bids in the knowledge that a large proportion of those bids will be unsuccessful."

Reinforcing their commitment to prequalification a three stage process is advocated;

a) Stage 1: *Invitation to contractors to prequalify.* This should involve an advertising exercise inviting interested firms to apply for prequalification documents. Advertisements should state that only those contractors considered as capable of performing the project satisfactorily will be issued enquiry documents.
b) Stage 2: *Issue and submission of prequalification documents.* F.I.D.I.C. have produced their own standard prequalification form (F.I.D.I.C., 1982). The prime areas it investigates in respect of applicants are; Company structure, Personnel resources (Directors and Key persons), Plant resources and Experience (geographical / relevant projects completed).
c) Stage 3: *Analysis of prequalification data and compilation of select list.* This should be achieved via assessment of the completed prequalification questionnaires in the context of: company (or joint venture) structure, experience, resources, financial stability and general suitability. Only then should contractors considered as being suitable be invited to tender.

Once formal submissions are received from those firms taking part, final evaluation can take place and it is suggested that a method for doing such should be established by the practitioner in advance. As under the ICE code, due to the inclusion of tender qualifications all submissions need to be evaluated on a common monetary base or datum, in order to reach as objective decision as possible.

2.4. A RESUME' OF CURRENT TENDERING METHODS

In simple terms, a client may opt to negotiate a contract with one or more contractors or to utilise competition. Alternatively, a combination of both may be used simultaneously but clearly, to promote a 'Dutch auction' would be an abuse of this. Pure negotiation is communication between the parties until such time as mutual agreement is reached. Competitive methods may be decomposed into open, selective or serial variations. All these variants are shown in Figure 2.1., and each may now be summarised in turn;

2.4.1. Open tendering

Open tendering involves the client or project administrator (eg., architect / consultant) advertising in local / national / technical press, displaying key information about the proposed project and inviting any interested contractors (wishing to undertake the work) to apply for tender documents upon which they may base their submission. Normally, frivolous enquiries are discouraged by requesting contractors to deposit a small sum of money for such documents.

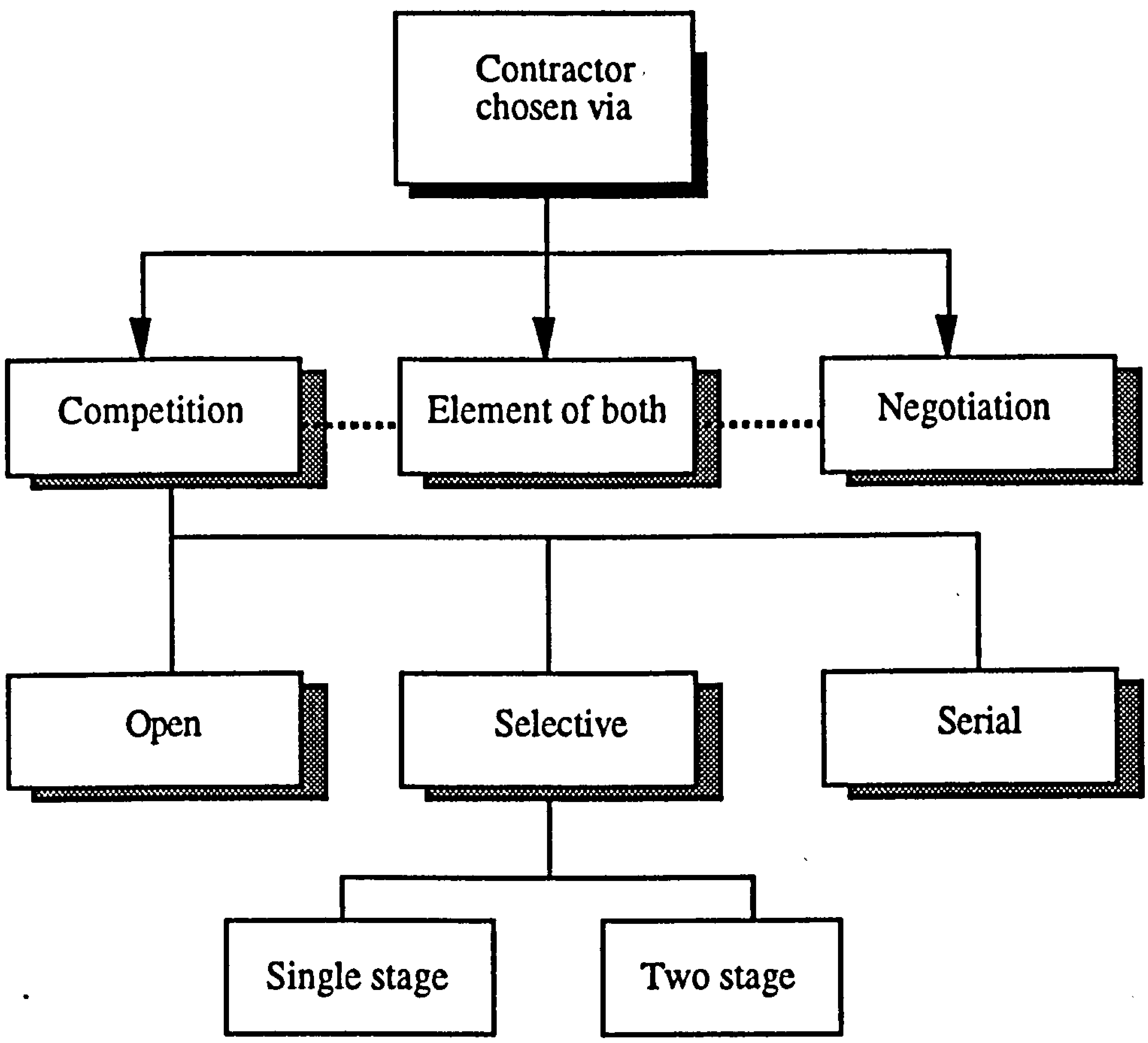
Because open tendering does not normally involve prequalification, this 'invitation to offer' does not oblige the client to contract with the lowest (or for that matter any) tenderer. A contract is only established when and if the client formally accepts a contractors' submission. This is a poor form of insurance for the client against contracting with a poor contractor.

The prime advantages / disadvantages associated with open tendering are;

2.4.1.1. Open tendering advantages

a) it allows any interested contractor to compete on equal terms for the award and therefore affords the opportunity for unknown firms (which otherwise may not have been included on a select list) to take part
b) favouritism is discouraged -open tendering ensures compilation of unbiased lists and is therefore ideal for local authorities in the context of their ensuring public accountability

Figure 2.1.
Contractor selection methods



c) the 'free market' environment generally encourages maximum competition - subsequently only bona-fide offers are submitted (in so far that offers should only be forthcoming from those contractors genuinely wishing to execute the works)

d) monopolies and 'ringing' are prevented. Due to the anonymity of those taking part, collusion amongst contractors is not realistically possible

e) the above combined, increase the probability that the client will receive a number of low tenders hence, open tendering encourages lower bid levels vis-a-vis other methods.

2.4.1.2. Open tendering disadvantages

a) long 'tender lists' prevail. These lead to much abortive work by contractors in tender compilation. These abortive costs must eventually be recovered and this is reflected in higher bids throughout the industry generally ie., higher construction costs. (This resultant defeats the underlying philosophy of the method)
b) the lowest tender may not be realistic in the sense that it may be from an unscrupulous contractor. Again, on the grounds of accountability it is difficult for the public sector to reject such low bids. Furthermore, such unscrupulous operators may be ill equipped to carry out the work. This may manifest itself during the project in; poor quality of product, contractor financial instability or sheer all round incompetence, all of which contribute to an unsatisfactory project outcome. In the worst possible outturn it is the client that pays for the contractors' business failure
c) too low prices from such (unscrupulous) firms reflect on the industry as a whole by depressing the prices of 'good' contractors to unreasonably low levels. What is more, 'poor' contractors rarely achieve client satisfaction and this reflects badly on the image of the construction sector as a whole
d) if a contractor has been awarded the contract on such a low price the firm may have an eye to try and make up any financial short falls via numerous claims. Therefore, the lowest bid may not be the most economic solution in the long term. Multiple claims are not conducive to good employer / contractor relations and unsettled claims often result in protracted, expensive dispute resolution
e) the above failings combined (particularly (c)) mean that many reputable contractors will simply not take part in open tendering. There is therefore a

tendency for 'less able' contractors to partake in open tendering exercises.

2.4.2. Selective tendering

As the name implies, this method involves the client or project administrator, inviting tenders only from those contractors chosen from a 'select' (otherwise known as a 'standing') list. Contractors on these lists will have been identified earlier (normally by way of a prequalification exercise) as being considered suitable to carry out the proposed project. Such lists may be;

a) drawn up by informal means for example, based on the clients past construction experience and / or the advice of consultant / advisors;
b) compiled by advertising for contractors to apply for 'invitation to prequalify for a select list' (note the difference from invitation to tender vis-a-vis open tendering);
c) constantly maintained by the experienced client who has an ongoing construction programme. This method finds favour predominantly with public sector clients (but can offer greatest potential for problems due to non cyclic prequalification review of those firms remaining on the list).

At this point it is interesting to note the comments of Hartman (1993) in respect to options (a) and (c); "You may rank contracts high risk if you have been doing business with the contractor for a long time. Familiarity breeds laxity of control and potential for abuse".

Because of the prequalification exercise familiar to this method, it is assumed that *all* contractors on the select list are competent, in that they are capable of executing the contract successfully. Therefore, final selection choice tends to favour the lowest bidder. Because of this, selective tendering is particularly favoured by the public sector, as it purports to give best value for money.

2.4.2.1. Selective tendering: the single stage option

Both the NJCC and the Department of the Environment state that they believe single stage selective tendering to be the most appropriate method of obtaining tenders for the majority of building contracts, but that for *early* involvement of the contractor (before the development of the design is completed), two stage tendering procedures (NJCC, 1983) should be adopted. The Code of Procedure for Single Stage Selective Tendering (NJCC, 1989) recommends that a short list of suitable tenderers be drawn up by the owner from either; the (experienced) employers approved list or from an 'ad-hoc' list of contractors of established skill, integrity, responsibility and proven competence to execute work of the character and size contemplated.

The NJCC further recommended that the number of firms invited should be limited to a maximum of six and that selection criteria for any short list should include firm's;

a) financial standing and record;
b) experience particularly comparable output over a similar contract period;
c) general experience and reputation in the area in question;
d) management structure and adequacy;
e) projected capacity (workload).

Emphasis is placed on the need for such lists to be reviewed periodically; "to exclude firms who's performance has been unsatisfactory and to allow the introduction of suitable additional firms". This emphasis on 'cyclic reviews' is essential in particular, where contractors remain on select lists for any period of time. However, as expanded upon in the following chapter, this is not always the case.

The following passage summarises NJCC recommendations on single stage selection procedure;

> Each firm chosen from the select list and included in the final selection should be sent a preliminary invitation to confirm their intention to tender. Those offering a positive response should be furnished with tender documents and subsequently be allowed a minimum of four weeks for the compilation of their submission. All tenders should be based on identical documents and qualified submissions should not be permitted.
>
> After submission deadline, the lowest tenderer should be requested to submit a priced Bill of Quantities. All but the lowest three tenderers should be notified that they have been unsuccessful (the second and third lowest are notified that they are to be kept in reserve as it were, should it be decided to reconsider their offers). Assuming the selection practitioner finds no errors in the priced Bill, and nothing else untoward is identified, the construction owner normally awards the contract to this lowest bidder.

2.4.2.2. Selective tendering: the two stage option

On large or complex projects it can be advantageous to take the contractor on board at an early stage in the procurement process, (The Aqua Group, 1990; see also Banwell earlier). Primarily this is because:

a) the contractor is able to offer specialist knowledge and experience into the design process which should save exceptional circumstance, contribute towards quality of end product, help avoid construction difficulties, assist buildability and, by virtue of the contractor being aware of the designers intentions, be able to offer alternative time saving construction solutions. This relationship between good 'buildable' design and successful projects has been highlighted by C.I.R.I.A. (1983). Their somewhat now 'famous' definition states; "Buildability is the extent to which the design of a building facilitates ease of construction, subject to the overall requirements of the building"

b) secondly, production can in most circumstances begin earlier and therefore be completed sooner so long as design and construction are programmed and integrated properly - see Figure 2.2.

However, ease of construction is not always easily achieved, design can influence not only the construction product but also the construction process. Buildability must be tackled at design level where the desired end product must be balanced with what is practical (Saville, 1992). When viewed in the above context, the potential benefits of contractor input at the design / pre-contract stages, can be appreciated. In short, the problems generally associated with 'traditional procurement' ie., the separation of design and construction elements may to some extent be avoided by using the two stage method.

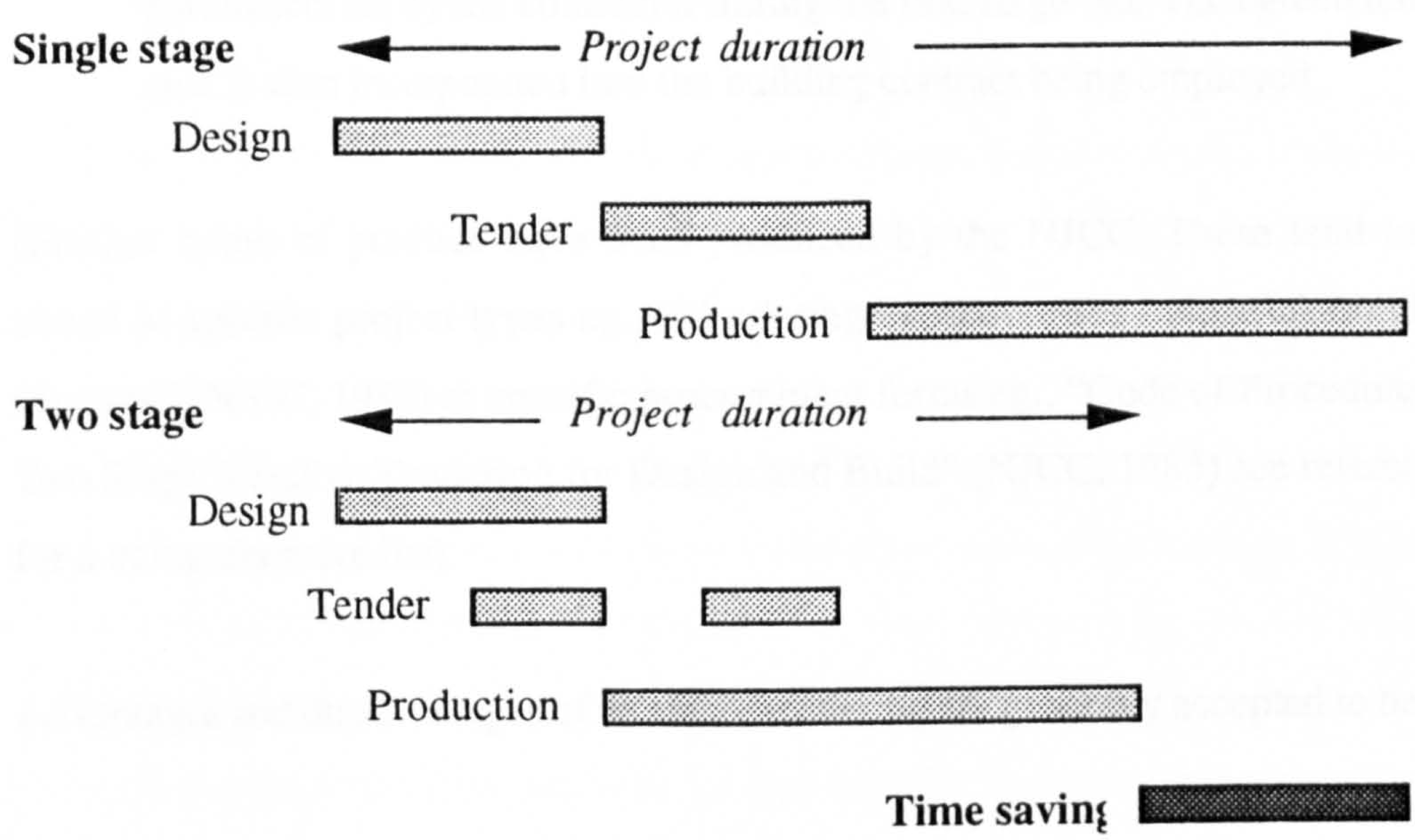
'Modern' procurement routes have evolved which also facilitate these benefits, for example: design build, turnkey and several which fall under the generic term of project management (Franks, 1990). *It is worth mention that procurement form alone is not a guarantee of success or performance* (Rowlinson, 1988).

However, procurement form and tender method should not be confused, although two separate entities, they may be combined. That is, two stage selection procedure may be used in conjunction with, or without these modern procurement methods as a means of taking a contractor on board earlier.

Should the two stage option be chosen then the NJCC Code of Procedure for such (1982) is most often observed -guidelines concerning approved lists and contractor selection in *this* document, generally mirror those suggested for single stage tendering.

Figure 2.2.

Single / two stage tendering -time comparison



It can be seen in this graphical example that the overlap of design / tender / production in the two stage method, shortens the overall project time-scale thereby representing a saving. (Horizontal axis represents arbitrary time units).

The aim of the first stage is to invite firms who have satisfied prequalification to submit a competitive bid based on preliminary documents. The nature of these documents will depend upon what stage the design has reached -if it is sufficiently advanced a notional Bill of Quantities may be available otherwise each firm will have to provide some form of analysis for their pricing structure, based on (for example) all-in labour rates, percentage additions, attendances, preliminaries etc.

The successful contractor will normally have started work on the project by the time the design is completed. At this later date, the second stage of the process involves agreement of the final tender sum based upon the quantities abstracted from the now completed design and, within the parameters set by the contractor during the first stage bid. The agreed tender sum is then incorporated into the building contract being employed.

(Further codes of practice have been produced by the NJCC. These tend to be aimed at specific project types eg., "Tendering Procedure for Industrial Building Projects" (NJCC, 1988) or specific procurement forms eg., "Code of Procedure for Two Stage Selective Tendering for Design and Build" (NJCC, 1985) see references for a comprehensive list).

Advantages and disadvantages of selective tendering are generally accepted to be;

2.4.2.3. Selective tendering advantages

a) only contractors of a known calibre are invited to tender. This means that more reputable firms are prepared to take part in such an exercise and that (in theory therefore) the lowest bid can be confidently accepted
b) due to the limited number of firms taking part, probability of the contractor winning the contract is greater. This means there is less abortive work in terms of tender compilation, which leads to lower overheads for contractors and therefore a reduction in construction costs generally
c) less competition enables contractors to include an adequate portion of profit in their bids. Increased profitability brings greater stability to the industry and promotes better construction practices. (Increased competition leads to keener prices which inevitably means lower quality. Selective tendering offsets this somewhat).

2.4.2.4. Selective tendering disadvantages

a) selective methods generally exhibit less competition which may nurture higher (priced) tenders
b) there may be a tendency for lists to remain unchanged. This discourages free competition
c) an element of opportunity exists for favouritism to influence the composition of select lists. The temptation for contractors to try and influence practitioner decision is therefore existent. Certain cases of serious corruption within local government have been uncovered in the past (Simpson, 1995).
d) bid values are generally higher than those received under open tendering however, this *should* reflect more competent contractors taking part and a better quality of completed product
e) contractors with adequate workload may be tempted to submit a high bid[3] rather than refuse to take part, for fear of offending the client and not being invited to tender in the future[4]
f) there is a much higher possibility of collusion between contractors, especially when order books are full. Firms might not therefore be desirous of the award and the scenario in (e) above pertains.

2.4.3. Serial tendering

Serial tendering has evolved as a useful tool where the client has an ongoing building programme. This may take the form of several 'small' contracts or a large project that is to be completed in successive phases.

In a serial contract the approximate extent of the series of contracts or phases is known when the offers are obtained and, the Aqua group (1982) contend that this may consist of three to a maximum of perhaps fifteen projects, or sub-projects.

[3] Often referred to as a 'cover.

[4] Where rotational lists are used, client's normally inform contractors with tender documentation that refusal to tender will not affect future invitations. Contractors would still rather submit a cover for the reason indicated.

An object of any tendering procedure must be to ensure that resources are used as economically and effectively as possible. Where an ongoing building programme exists, then such continuity should mean that this aim will be better achieved if all the work is carried out by the same contractor. The main reasons for this increased efficiency are;

a) that the main contractor becomes familiar with the organisation and management of resources (economies of scale)
b) the contractors operatives will become more efficient via the repetition of tasks.

This saving in resources should ultimately result in financial gain to the client, but should also secure consistent quality and good working relationships stemming from mutual understanding and dependency between client / contractor. The former point was reinforced by the Aqua group who confirmed that it is not satisfactory only to establish that *there is* a saving in resources, but that the client is entitled to gain from this saving, after all, the continuity was provided solely by the virtue of the clients construction programme.

Prequalification normally takes the form of interviews with potential tenderers, culminating in a short list of suitable firms. These contractors are then invited to take part in a selective competitive tender. The tender is based on a master bill, which comprises most of the items envisaged in the series of projects. This is on the understanding, that a series of contracts for similar projects will be awarded to the firm with the most favourable bid -submitted in line with the conditions contained in the *original* bill.

One particular danger associated with serial tenders is that small errors of documentation (which would not amount to much in the context of an individual contract) may be much more significant because of the multiplier effect stemming from the repetition involved.

2.4.3.1. Serial tendering advantages

a) it allows both parties to carry out advance programming and planning with greater accuracy thereby promoting efficiency and removing uncertainty
b) this generally leads to improved two-way relations and encourages an input from the contractor in the design and planning of the customers requirements
c) it normally gives a faster start on site due to shorter pre-contract periods
d) it affords the client an experienced contractor -problems having been realised on the previous contract / phase
e) it re-uses an established site organisation and management team
f) there are increased efficiencies due to economies of scale and repetition.

2.4.3.2. Serial tendering disadvantages

a) due to the client knowing the contractors prices in advance, there may be a tendency for the client to have a bias towards using the low cost items in the BOQ on future contracts or phases
b) it reduces the availability of work under competitive tendering and therefore excludes certain contractors. Ultimately, this stifles competition.

2.4.4. Negotiated tenders

Under this system, the tender sum and contract conditions are agreed via negotiation between owner and contractor. This method is used when the client may feel that the element of competition may be dispensed with altogether and, that negotiation is the optimum solution for selection under the given circumstances. Such an instance may be where a similar contract has to be assigned to one that the contractor is currently undertaking or, has recently executed for the client.

However, the process need not entirely exclude competition. Under normal negotiated tendering practice using a Bill of Quantities, the contractor is selected at an early stage and this is conducive to implementation of the two stage selection procedure described earlier.

On grounds of *contractor* accountability it should be demonstrable to the client that negotiation is advantageous in *that instance* over any other selection method. For example;

a) the client may have a business relationship with the contractor which will yield some other benefit such as reciprocal trading
b) the contractor may be working for the client already eg., a negotiated continuity contract
c) a contractor may be the only one available with the expertise or specialist plant required to carry out a particular project or service
d) in times when the industry is buoyant (difficult to imagine at this time!) it may pay to negotiate -tenders may well be 'loaded' by firms already working to capacity.

Such accountability is particularly relative to the public sector who need to demonstrate the positive advantage/s of negotiation accruing to the public from using this method. This point was highlighted by Banwell in 1964 and more recently by the Aqua group in 1982.

2.4.4.1. Negotiated tendering advantages

a) it affords quicker appointment of the contractor and therefore an earlier start on site. The advantages of early contractor involvement already discussed in this chapter are therefore applicable .
b) negotiation facilitates integrated communication on design and construction

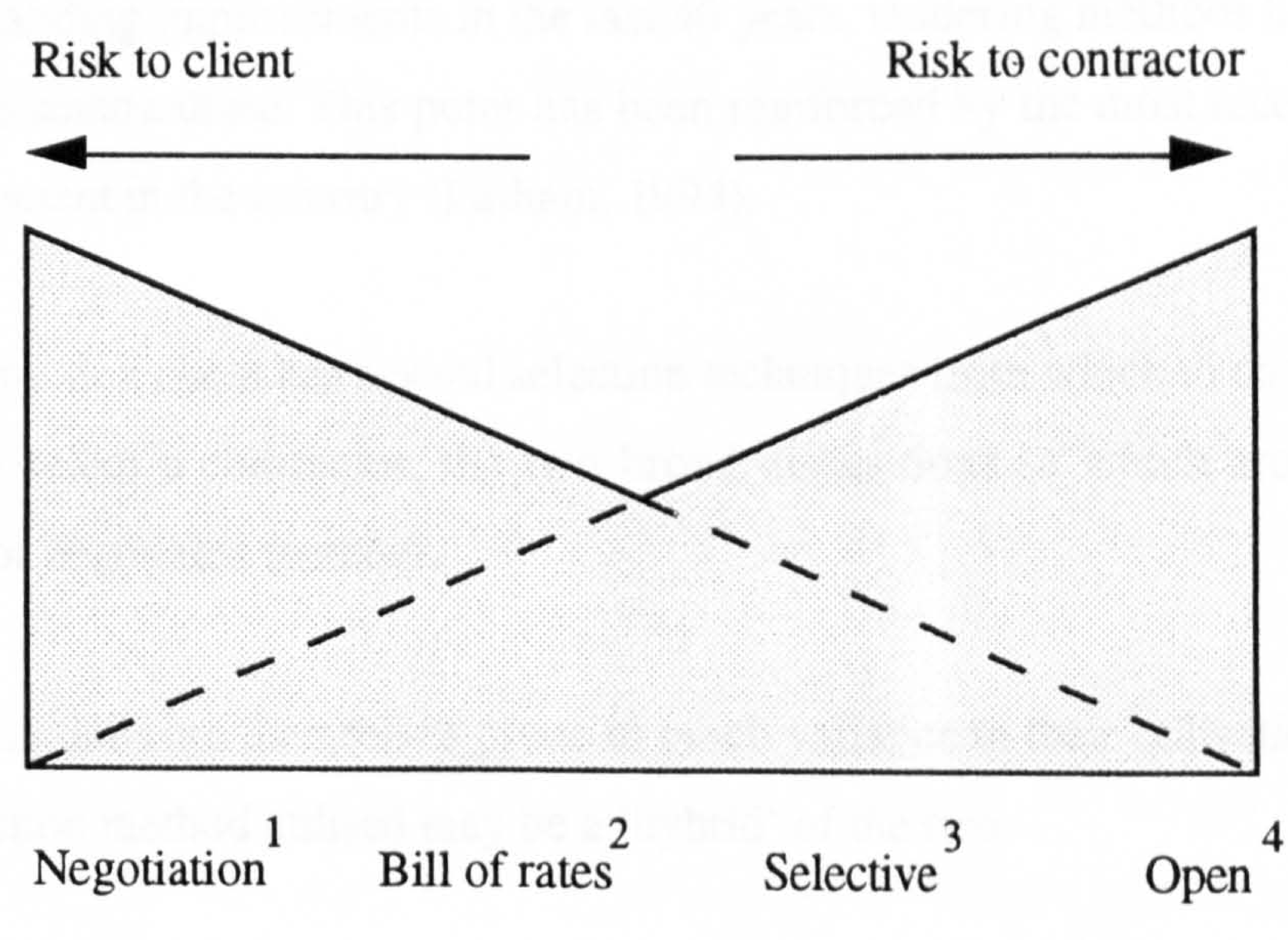
c) it tends to generate team spirit in the project coalition thereby reducing many claim items during contract and final account.

2.4.4.2. Negotiated tendering disadvantages

a) negotiation may result in an increase in costs to the client over more competitive tendering methods
b) it results in a loss of time if negotiations prove unsuccessful
c) there may be a tendency toward a lack of accountability on the part of the contractor.

In conclusion, the fundamental tendering options each have their own inherent advantages and disadvantages. Figure 2.3. apportions the financial risk associated with each.

Figure 2.3.
Apportionment of *financial* risk and contractor selection method



Adapted from Rowlinson (1988)

Commentary to Figure 2.3;

[1] Negotiation may contain an element of competition also, which would negate financial risk to the client somewhat.

[2] A contractor may be required to tender on the basis of pricing a schedule or bill of rates under any tendering method.

[3] Selective is a generic term for any of the variants discussed earlier.

[4] Unlimited number of tenderers -open to all.

2.5. SUMMARY

Pre-1950's the majority of clients procured construction work via traditional means and assigned contracts by way of open tendering methods.

The Simon Committee (1944) initiated a shift away from open tendering practice towards more selective / negotiable methods.

Notwithstanding improvements in the last 40 years, tendering methods have failed to become standardised. This point has been reinforced by the most recent review of procurement in the industry (Latham, 1994).

The construction client has several selection techniques from which to choose when having to select a contractor, the two broad distinctions of which are selective methods or negotiated methods.

Such distinctions are themselves prone to much variance in their utilisation and the final selection method utilised may be a 'hybrid' of the two.

CHAPTER 3

A CRITIQUE OF PRESENT-DAY SELECTION PROCEDURES

3.0. INTRODUCTION

Chapter 2 introduced the research theme and presented an overview of contractor selection methods. This chapter further dissects current practices to reveal their most prominent weaknesses. This exercise justified the need for some revision of existing techniques, but moreover, identifying the necessary remedies for such weaknesses helped serve to mould the design of an alternative contractor selection model. It is pointed out, that the remedies cited are solely the opinions of the author.

3.1. THE CLIENTS' STANDPOINT

It would be insufficient to simply identify then cite failings of current practices, without firstly understanding the implications of such shortfalls for the client. "Clients are the key to the whole construction process. Since ultimately they fund it their wants and needs should be paramount" (Latham, 1993). An appreciation of the contractor selection process *from the client's standpoint* is therefore necessary.

As long ago as 1979 the Institute of Building pointed out that; "Shortcomings occur in both the public and private sectors. These shortcomings often result in the client having difficulty in getting the best value for money. Most of the problems clients encounter, originate before the contractor has been appointed with many of them being made worse because the wrong contractor, or the wrong system of employing him was chosen" (I.O.B., 1979). The intent of the tender process should be to obtain for the client, the most competitive price for the construction given prevailing market conditions and, to identify a contractor who will meet client aspirations given that price. All that the process actually achieves is to identify the lowest estimated cost (Hartman, 1993).

3.1.1. Initial considerations

Primarily because of the complexity surrounding acquisition, the products of construction are normally *purchased* before they are *manufactured.* This means that the more usual methods of product appraisal such as pre-purchase comparison or approval, cannot be applied. Therefore, once the commitment to purchase is made it is the subsequent success or failure of the construction manufacturing process, that determines the ultimate level of satisfaction attained from the exercise by the client (Mohsini & Davidson, 1986).

For most other sectors of industry such a scenario is uncommon, rather, it is generally a case of the purchaser either;

a) selecting from ready-manufactured goods whereby the application of preference, or predetermined selection criteria (eg., size, colour, life cycle, capital cost etc.) to the range of products, allows a preferential or fully rational choice to be made; or

b) where the purchaser desires a bespoke product then evaluation of the potential *manufacturers* of such products must take place. This typically involves enquiry into company reputation, image, quality of product etc. Having decided *who* is best able to fulfil this need, the purchaser may then place an order.

In the context of the construction industry (a) is not normally practical. An exception would be where a client discovers an existing (ie., already constructed) product that placates his need, whilst also being suitably geographically located (the latter is what sets construction apart from other sectors of industry -the product once manufactured cannot normally be 'delivered' or moved to meet geographical demand). A simple example of scenario (a) is the private individual purchasing a house.

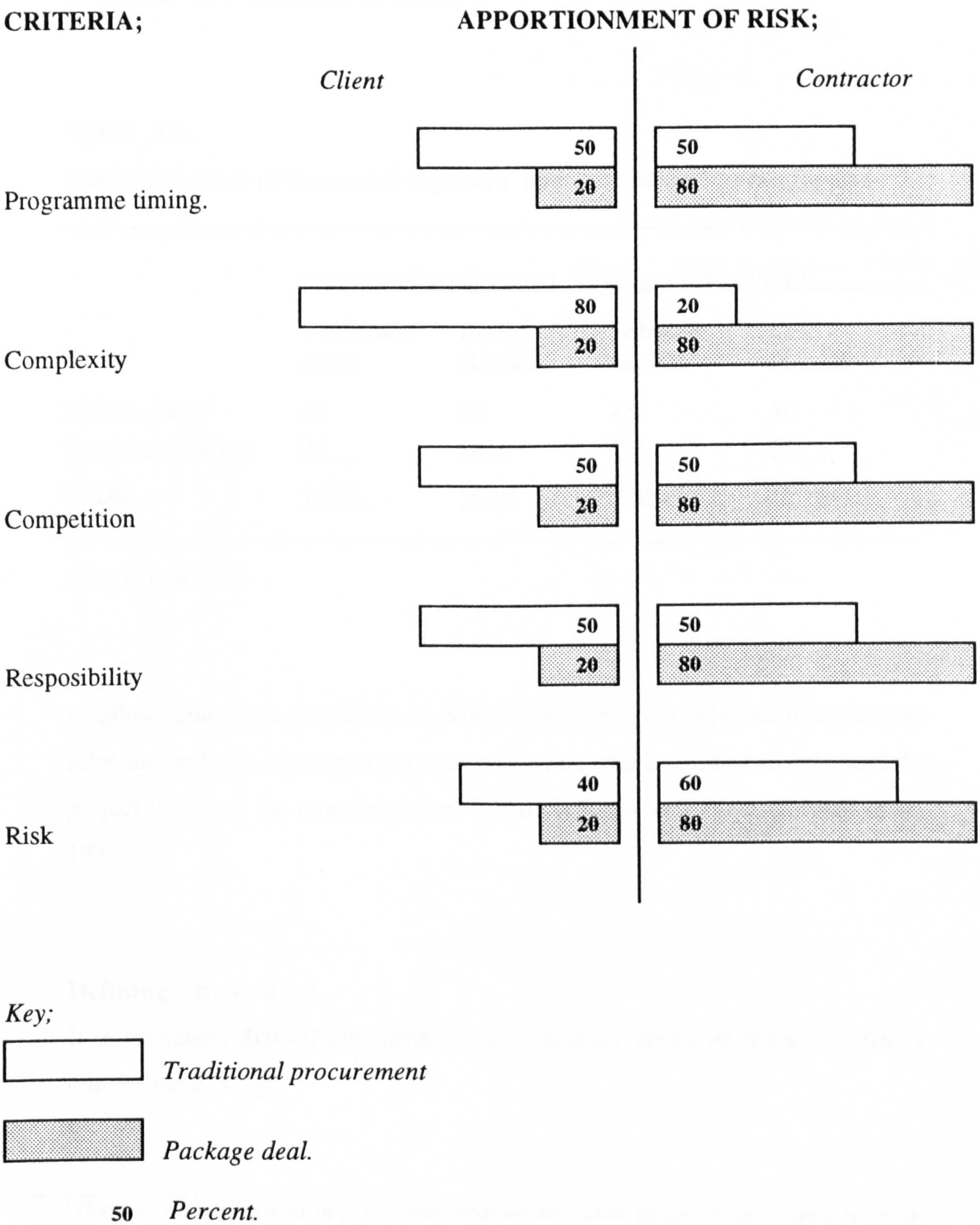
Option (b) is somewhat nearer the role that most construction clients have to perform. However, even this is only representative to a point. This is because construction manufacturers are usually an amalgam of design, management and production components (the project coalition), specifically assembled for *each individual* product. Hence, construction coalitions (manufacturers) are unique to almost every project (product).

3.1.1.1. Package deals

The boldest exception to this last statement arises from the advent over recent years of construction companies offering 'package deal' services such as Design and build, Management contracting and Turnkey (c.f. Franks, 1990). In providing this integrated design / management / production facility, package deal companies better fulfil the more generally perceived role of a *manufacturer*. This is because the (normally in-house) design / production components, are not so prone to separation as they would be under the traditional procurement route.

That existing contractor selection methods are unable to predict a successful project outcome is evidenced by the increasing number of clients now utilising these alternative (package deal) methods of procurement (Sullivan, Harris, 1986, Latham, 1993). Design and build, Management contracting and Construction management are increasingly prevalent (ibid; Holt et al, 1995A). Not least, this is because clients perceive these procurement methods to apportion a greater degree of risk onto contractor's shoulders (Watkinson, 1992; Holt et al., 1993A) -see Figure 3.1.

Figure 3.1. Apportionment of risk: Traditional / Package Deal Procurement



Adapted from; Watkinson, (1992).

Subsequently, financial exposure to the client from choosing the wrong contractor is reduced[1] as demonstrated in Table 3.1.

Table 3.1.
Apportionment of *financial* exposure and contractual arrangement

	Contractual arrangement (risk apportionment %)			
	Traditional route	Design & build	Schedule of rates	Cost plus fee
Risk to client;	65	20	65	80
Risk to contractor;	35	80	35	20
Totals;	100%	100%	100%	100%

After Brook 1993

It follows that client satisfaction is primarily a function of judicious manufacturer selection, indeed, selecting a contractor in whom can be confidently reposed the project is one of the most important decisions faced by a client (Russell et al., 1992).

3.1.2. Defining client need

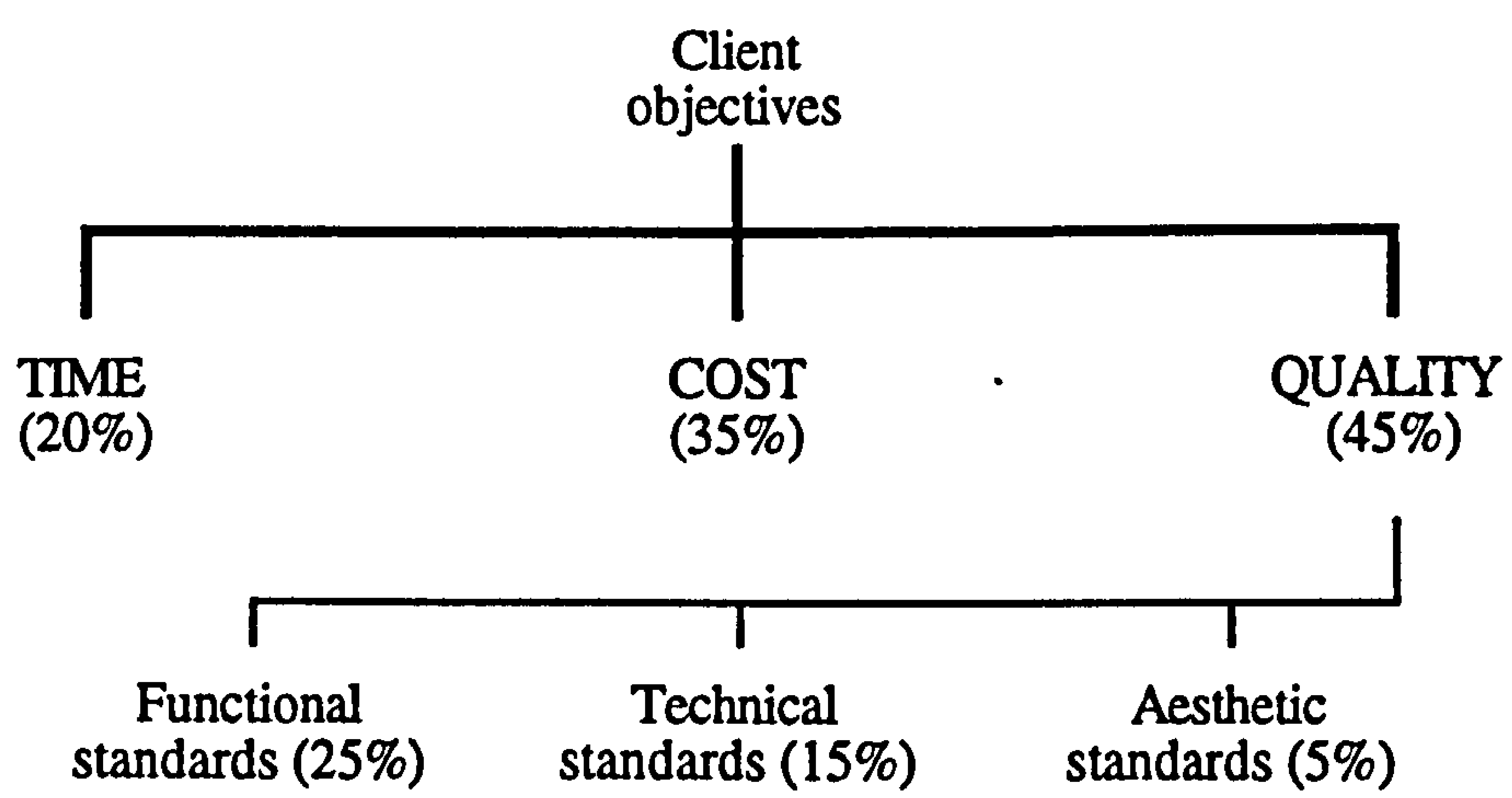
It is suggested that all purchasing in any industry pivots on three superlative criteria, these being;

[1] Decisions regarding choice of *procurement route* are beyond the bounds of this research, however, further reading on the subject may be commenced under Skitmore and Marsden (1988), Franks (1990) and Turner (1990).

1) *Time* -the client wants the product completed as soon as possible.
2) *Cost* -the client wants to buy the product at the lowest possible price.
3) *Quality* -the client wants the product to be of the highest possible standard. (Odusote, 1990; Watkinson, 1992; Holt et al, 1993C).

Humphries (1994) identified that construction clients consider these criteria to have overall levels of importance as shown in Figure 3.2. Cost is obviously of prime concern, but the prudent client will always be seeking to balance this with project time and project quality to secure the best all round value for money.

Figure 3.2.
Time, cost and quality -overall levels of importance



Watkinson (1992) suggested that any *combination of two* of these criteria can be easily achieved but rarely if ever, all three. Table 3.2. shows his list of 'compromised' criteria in relation to recognised contract routes.

Table 3.2.
Attributes of recognised contract routes in terms of time, cost & quality

Combination of criteria	*Criterion compromised*	*Contract route*
Time & Quality	Cost	Management
Quality & Cost	Time	Traditional
Time & Cost	Quality	Design & Build

Adapted from Watkinson (1992).

Referral to Bresnen et al (2.2.4.) confirms that the traditional procurement route does tend to give time overruns and, that achieving time and quality leans toward increased cost. However, Watkinsons' postulation contradicts with the findings of the Building Economic Development Committee (BEDC, 1983) who said of these three criteria; "The clients needs may prescribe that all three are held in balance or that one may take precedence over the other two, however, contrary to popular belief the three are not mutually exclusive -good quality *can* be achieved at reasonable cost and in good time."

Griffith (1992) contended that in practice there will always be a trade-off between the three main aspects of time, cost and quality, as the client tries to balance these variables. Furthermore, that time and quality can always be manipulated within the parameters of the project but more often than not, this will have the consequence of increasing the project cost.

It can be ascertained from the above, that the level of importance attached to each of these superlative criteria will vary from client to client and from project to project.

"Most clients compromise their objectives to achieve what is most important to them. This suggests that the weight which the client attaches to each of these basic objectives, will most likely have a dominant influence on the contractor selection decision" (Baker & Orsaah, 1985).

Research by Fellows (1988) found that hierarchal classification of the criteria in respect to three specific client groupings exhibited the features as shown in Table 3.3. Fellows contended that public sector clients are predominantly concerned with public accountability which leans towards cost limits and specification stipulations, whilst the private sector are more attentive to the ramifications of time -notably due to it's impact upon profitability.

Table 3.3.
Hierarchal classification of Time Cost & Quality by client groups

	Classification		
Rank;	*Clients: Private*	*Clients: Public*	*Consultants/Contractors*
1.	Time	Quality	Quality
2.	Quality	Cost	Time
3.	Cost	Time	Cost

Adapted from Fellows, 1988.

The construction Industry Council have produced client guidelines for the procurement of professional services (C.I.C., 1994) and in this context, suggest weighting ranges for quality *vis-a-vis* price. (Not normally having direct influence on production, time is not such an important factor). These ranges are summarised in Table 3.4.

Table 3.4.
Weighting of quality *vis-a-vis* price

Example categories	Discretionary weighting range†	
	Quality	*Price*
Consultancy work eg., arbitration, feasibility studies, litigation support, value engineering.	88% up to 98%	12% down to 2%
High complexity projects eg., mass transit, power generation, hospitals, sports stadia, motorways.	78% up to 94%	22% down to 6%
Complex projects eg., airport terminals, sewage treatment, shopping centres.	68% up to 85%	32% down to 15%
Uncomplex projects eg., banks, apartment blocks, car parks schools, sewage systems	47% up to 68%	53% down to 32%
Simple projects	10% up to 45%	90% down to 55%

†$\sum$ *Quality weighting plus price weighting = 100%*

It can be seen that the CIC rate quality as high as ninety eight per cent (ie., cost two per cent), for consultancy work. As an example, they recommend that for feasibility studies price should account for no more than five per cent of the overall value assessment, but conversely, may rate as high as ninety per cent for simple, straightforward commissions.

Client experience of construction will influence their expectations of the industry (Brook, 1993) and obviously time, cost and quality will be 'weighted' by them (implicitly or otherwise) in line with this anticipation. The importance thus attached may be 'consulted' when monitoring the progress of the project. Indeed, such expectations even if implicit in nature, will be used as a means of adjudging the final outcome of the completed project -in terms of overall satisfaction.

It is essential therefore, that in striving to attain a successful project outcome a method for selecting the contractor must encompass evaluation of candidate firms in the context of: what is their potential for achieving these client requirements - time, cost and quality? As will become clear later in this chapter current selection methods tend to fail in this objective!

At this juncture, we may conclude that the client's standpoint in terms of selecting the 'best' contractor to be entrusted with the project may be summarised as follows;

a) deciding to utilise an alternative procurement form to the traditional method, cannot be relied upon as a guarantee of project success or performance (Rowlinson, 1988);
b) no matter how the construction product is procured, a method of contractor selection must be utilised;
c) in selecting the contractor, evaluation must encompass assessment of the organisation's ability to produce a product on *time*, to budgeted *cost* and of acceptable *quality*.

"A suitable evaluation methodology must be capable of measuring a contractors potential relative to all of these clients objectives" (Diekmann, 1979).

3.2. PREDOMINANT FAILINGS OF CURRENT SELECTION PRACTICE

A comprehensive review of existing literature on contractor selection methods and trends, combined with investigation of prequalification questionnaires and liaison with client organisations, has identified four main areas of deficiency. These may be summarised as;

a) Lack of a universal approach;
b) The long term confidence attributed to prequalification;
c) Final selection and tender evaluation methods;
d) Reliance on subjective analysis.

Each may now be investigated in turn.

3.2.1. Lack of a universal approach

As was demonstrated in Chapter 2, selection codes of practice and procedural documents abound (NJCC, Various; ICE, 1980; FIDIC, 1982; ACE, 1993; CIC, 1994). Notwithstanding this situation, contractor selection practice remains very fragmented. Recommendations, methods employed and the extent to which the process is implemented exhibit much variation. (A similar situation has been noted in the U.S.A. see Birrell, 1988).

Primarily, this has been brought about because supporting documents tend to limit their advice to very broad recommendation. This is prone to subjective interpretation by practitioners. As an example, investigation of contractor's financial stability is universally recommended;

> "The firm's financial standing and record should be considered" *Code of Procedure for Single Stage Selective Tendering* (N.J.C.C. 1989).

> "The contractors financial standing should be assessed, normally including examination of annual reports (if a public company), along with a letter or

confidential report from the firms bank." *Guidance on the Preparation, Submission and Consideration of Tenders for Civil Engineering Contracts* (I.C.E. 1983).

"The prequalification procedure should take account of both technical and financial aspects" *Procedure for obtaining and evaluating tenders for civil engineering contracts* (F.I.D.I.C. 1982).

Nonetheless, it appears that what is missing is more specific guidance as to the actual mode(s) of evaluation best employed by the practitioner, for the purpose of evaluating each criterion indicated. For instance, if one considers in more detail financial stability, then should practitioners rely on bank and / or credit references, an analysis of turnover history or ratio analysis of annual accounts? Perhaps they should all be investigated? Having decided which of these variables to investigate, then what specific evaluation methods should be adopted? eg., for ratio analysis of accounts alone then; i) what ratios should be applied? ii) to which years figures? iii) what critical limits should be observed and iv) should trends be examined?

Regarding ratio analysis, Abidali (1990) discovered wide variation in the application of financial accounting ratio's applied to contractors when being evaluated by construction owners. He refers in his work, to a London-wide survey of twenty five Local Authorities, twenty four of which *did* examine contractor's financial accounts. Only eleven authorities preferred to see accounts for the last three years (trend analysis), a further eleven preferred to see accounts for the last two years and the remaining two based their appraisal on the most recent year's accounts alone. Eighty per cent of those surveyed *did* use financial ratios in their appraisal which relied heavily upon an assessment of liquidity (current ratio, acid test etc., see Holmes & Sugden, 1992; Pilcher, 1992), whilst six authorities used z-score analysis (mainly Altmans z-score developed in the USA in 1968). Finally, twenty two of the twenty five authorities imposed some form of limit on the value of contracts which may be awarded to certain contractors (often determined by expressing the proposed contract value as a percentage of contractor's previous years turnover).

Hence, it can be seen by considering *this one variable alone* (which is only part of the cocktail of criteria recommended for evaluation by most codes of procedure), there is tremendous scope in regard to potential methods of assessment.

The specific area of contractor evaluation has hitherto received minimal research or questioning (Russell et al 1992). The consequent lack of detailed guidance combined with the above scope for broad interpretation would therefore seem (in part at least), responsible for the trend of practitioners developing their own bespoke evaluation methods.

This situation has given rise to much individual inclination and preference. A broad example would be the difference in emphasis exhibited between public and private sector client groups. The public sector tends to place importance on such criteria as quality assurance and race relations policy;

a) "Companies will only be considered for inclusion on an approved list who have appropriate Q.A. registration to BS 5750 or who are intended to apply for such registration within 12 months from the date below"
Source: County Council approved list advertisement "Contract Journal".

b) "Is it your policy to comply with the statutory obligations under the Race Relations Act 1976 and not to treat one group of people more favourably than others because of their colour, race, nationality or ethnic origin?"
Source: District Council prequalification questionnaire.

In contrast, the private sector reposes greater priority to evaluation of such criteria as company experience, ability to complete on time and ability to complete within budget (Fellows, 1988). In short, the emphasis placed upon and expertise of contractor selection varies considerably from organisation to organisation. Most organisations feel satisfied with their own selection system (see questionnaire survey of practitioners later in Chapter 4). It is not until a system problem occurs that inherent weaknesses are realised[2]. Furthermore, this 'go it alone' approach is a feature of British industry ie., to classify internal affairs as confidential! Subsequently, the results of methods employed during contractor selection, whether good or bad, are not shared and cannot benefit industry as a whole.

Present fragmented and individualistic practice needs to be replaced. This would best be achieved via consolidation of existing idea's and trends into a new quantitative framework -a common, more standardised method of contractor selection formulated to be capable of universal adoption by the industry (c.f. Latham, 1994). Based upon time proven principles and utilising the best of the bespoke systems presently in use, such an improved approach could further be reinforced with the findings of ongoing research into this subject. Construction could then implement a 'minimum standard' universal selection technique to which contractors would have to conform, indeed, very often aspire to.

Furthermore, if a 'standard' approach were adopted it would facilitate feedback to those contractors who were unsuccessful at being invited to tender. If the feedback also detailed the reasons for them being 'unsuccessful' it would encourage firms to audit and rectify their failings in order that they may increase their chances of success in future (see results of contractor survey Chapter 9). Indeed, Humphries

[2] One client liaising with the author during this research had a contractor fail just two weeks after commencement of a large refurbishment contract. The client initially believed their system to be adequate but, retrospectively, admitted that it needed improvement -if only they knew how to properly implement such improvement.

(1994) found that contractors rated *feedback* amongst the following top four most important issues, when deciding which projects to tender for; i) contract period, ii) sub-contractors, iii) type / size of job, iv) feedback from client. Any system that promoted contractors to address their areas of weakness, would encourage positive actions to the benefit of clients *and* the users of construction facilities.

3.2.2. The long term confidence attributed to prequalification

Prequalification has aptly been defined as a process which involves the screening of contractors by owners, according to a given set of criteria as to determine their competence to execute the work associated with a given project (Russell, 1992). Without argument, there is considerable importance in the prequalification of potential tenderers. Without it selective tendering as we know it would not be possible and the subsequent 'free for all' would rejuvenate the days when open tendering enjoyed prominence.

Of prequalification, Baker and Orsaah (1985) said; "Prequalification provides some degree of confidence in the customer that the firms selected will meet client needs". Such confidence however, can only be a function of the integrity of the prequalification regime (Holt et al.1993B; C).

Unfortunately, many current prequalification regimes leave something to be desired, not least because of the confidence that their user's place in the corporate stability of contractors over the longer term. It is based upon successful prequalification that contractors are normally admitted onto a select list, or at very least afforded future consideration for an invitation to tender. With this in mind two points are worthy of consideration;

a) *The prequalification process may not have been as comprehensive as it could or indeed should have been:* as previously demonstrated, the entire aspect of contractor selection is prone to diversity and variance. It is debatable as to how good an organisation's prequalification process really is. Prequalification most probably entails as much variation as witnessed in tendering procedure generally (ibid).

b) *Whilst actually on the standing list any further investigation of the contractor organisation is not often obligatory:* a contractor may very well have prequalified with excellent prospect. However, should that contractor have to remain on a select list for any amount of time[3] it is conceivable that the firm may witness drastic changes within its corporate structure (liquidity, management / plant resources etc.). This is particularly so in view of prevalent macroeconomic and market forces. More often than not under current procedure, once tenders have been submitted from these prequalified contractors the major discriminating factor in final selection is cost (bid value). It follows, that any such negative corporate changes (ie., reduction in an organisations performance potential and / or financial stability) is not necessarily detected under current tenderer evaluation procedure.

Subsequently, there is the ever present risk that the client may ultimately enter into contract with a company, who's ability to execute the project is something altogether different from what was apparent *at the time of prequalification.*

Not all prequalification regimes exhibit these failings. Some organisations do prequalify contractors *per project*, however, this improved approach is more the exception than the general rule. Most organisations (particularly public) utilise continuous standing or rotational list(s) which may only be prone to review on an annual basis, sometimes at longer intervals than this.

[3] As, has been witnessed by the author to be commonplace with those clients who have an ongoing construction programme, such as the public and utilities sectors.

Even if armed with only a limited appreciation of the susceptibility of construction companies (particularly in financial terms), one can appreciate how much more prone to failure a contractor *may be* one year after initial prequalification. And yet, in the majority of cases, without further investigation, a contract may be awarded to that company if it's tender sum is the most favourable!

The fundamental purpose of prequalification remains desirable but it's separation from tenderer evaluation / final selection, by way of a time interval must be reduced to a minimum. Where standing lists continue to be favoured, contractors thereon should in all cases be subjected to a prequalification review. This should be performed on a strict predetermined, cyclic basis, to remove those companies unfortunate enough to have suffered any form of corporate decline.

A superior option and the one in tune with a proposed alternative selection model, is to integrate prequalification as part of the *overall* selection process, at all times performed just prior to the invitation-to-tender stage. This would render prequalification more dynamic by furnishing the practitioner with real time information, that is, the *current* standing of a contractor[4].

"Even if selecting a company which has been employed previously, the client should still review the contractors' capabilities for the particular work in question (prequalification as part of the overall process of selection again), since all construction projects are of a one-off nature and therefore different. Changing circumstances within construction are ever present and such variability can impact significantly the contractor selection process by the client" (Griffith, 1992).

[4] There will obviously be a cut-off point in terms of project value below which this approach would not be practicable (see 'relationship between cost and value of information: Chapter 5). However, when this point is reached then it is less likely that a comprehensive tendering procedure is being employed eg., smaller projects more prone to direct negotiation.

3.2.3. Final Selection and Tender Evaluation Methods

As confirmed, the majority of tender evaluation techniques rely predominantly on tender sum. For example, a study conducted by Baker and Orsaah (1985) found that almost eighty seven per cent of clients based their selection decisions on price, whilst eighty four per cent of contractors considered price as the most important factor in the winning of contracts (see also Chapter 4, Tables 4.1. and 4.2.).

This was further substantiated by Merna and Smith (1990) who conducted a two year research into the methods of prequalification and evaluation of bids, employed within the UK public sector;

"Clients use systems of bid evaluation which conform to several guidelines but exhibit considerable individual variation (*lack of a universal approach* earlier). However, each system of evaluation is dominated by the principle of acceptance of the lowest price" (ibid). Furthermore, Griffith (1992) pointed out that bid selection is nearly always based on the lowest tender, but lowest tender is not always the most economic solution in the long term.

Concentrating upon tender sum as major discriminating factor, is not only high risk but more importantly, shortsighted. Consider J.Ruskin C19th;

"It is unwise to pay too much but it is worse to pay too little. When you pay too much you loose a little money that is all. When you pay too little you sometimes loose everything because the thing you bought was incapable of doing the things it was bought to do. The common law of business balance prohibits paying a little and getting a lot -it can't be done. If you deal with the lowest bidder it's as well to add something for the risk you run and if you do that you will have enough to pay for something better" (CIC, 1994).

It follows that lowest bid may not be the least expensive choice, therefore the client is faced with the predicament of;

a) accepting 'lowest bid' as the criterion for selection of the contractor but subsequently;
b) running the risk of poor performance by that contractor during the project life (Birrell, 1988), (cf. also low bids / unscrupulous operators -highlighted as long ago as 1944 by the Simon Committee).

This means there is always the possibility of these 'performance' risks evolving into detrimental aspects, for example, actual completion date may be overrun with consequent delay of the project use. Capital thus far invested is therefore committed and unable to be put to work elsewhere, whilst potential generation of revenue from the investment is postponed. The scenario worsens when one considers the time value of money -most construction projects utilise capital borrowing.

Other risks stem from poor quality performance by the contractor. Low quality of the once completed investment, can have a deleterious effect on the clients' business activity if that quality is less than it should be.

Contractual (liquidated) damages may in some instances alleviate the client's situation somewhat but they do not remove the risk stemming from poor or inadequate performance by the contractor during construction (Birrell, 1988). Furthermore, one could reasonably advocate that the client would much prefer the project to be completed on time and to acceptable quality rather than receive financial recompense for non-performance by the contractor.

The worst scenario must be, financial failure of the contractor. This can prove disastrous for the client. Here the dilemma is clear: there is temptation to contract with the firm offering the lowest price, but will that price add weight to a contractors potential for collapse? (Consider: is the low bid a final attempt at maintaining an inward cashflow by a firm with liquidity problems?) As Griffiths (1992) confirmed; "A contractor may submit a bid with an extremely low, if any, element of profit included. In a poor economic climate a contractor may have to 'buy work' simply to maintain continuity of employment".

Financial failure leaves the client with a part completed product and the need to take on board another contractor, this coupled with subsequent delays arising from inevitable disputes, regarding the ownership of materials, creditors vying for settlement etc. This mess has to be remedied, pushing the occupation or utilisation date ever distant and incurring extra cost to the client; "ultimately it is the client that pays for the contractors business failure" (Hartman, 1993). Concern over corporate collapse has been exacerbated by the realisation that damage is not limited to the quantifiable cost to employees, creditors and the failing company's owners: suffering by the client is also inevitable. Selection on the basis of price is not a logically compelling selection strategy (Diekmann, 1979).

Tender evaluation requires a broader appraisal technique and perhaps here, the building sector could look to the civil engineering scene. They being the recipient of qualified tenders have to adopt an evaluation method encompassing many more facets. Could it also not be argued that NJCC recommendations which deny qualification of bids in the building sector, may not always be in the best interests of the client? The optimum bid is the lowest priced, evaluated bid which has undergone a process of assessment to identify and where necessary to price, the consequences inherent in the submission. (Merna & Smith 1990).

Tender sum is no means of predicting the final project cost and is an unsatisfactory basis for selection even if the tenderer satisfied prequalification earlier. For many of the reasons discussed hereto, very often tender sum bears little resemblance to final contract sum; "there is no definite relationship between a low tender sum and a low outturn price" (Merna & Smith, 1988).

Tender evaluation should include a secondary investigative element concentrating upon the contractor in the specific context of potential in relation to the *proposed* project. "Project specific criteria will evaluate if a candidate contractor can provide unusual expertise or specialised facilities required by the project" (Russell, 1992). The results of this secondary procedure could then be merged with tender sum thereby creating an aggregated final score and ranking (see P3 score Chapter 7 later). Such an 'all embracing' resultant would better be able to predict potential (contractor) project performance.

Finally, it is worth mention that Humphries (1994) found a distinct lack of understanding by estimators of the factors influencing construction prices -which is reflected in levels of tender (prices) submitted. He goes on to logically argue that therefore, if the price quoted by a contractor *was* accurate and 'acceptable' then the client *could* base selection on other factors, ie., discriminate on cost.

3.2.4. Reliance on subjective analysis

Methodologies presently employed by practitioners tend to involve information which is often subjective and imprecise. Contractor selection has subsequently become something of an 'art' where very often, subjective judgment based upon practitioner intuition and experience prevails as an essential part of the process (Russell & Skibniewski, 1988).

Many of the selection procedures currently in use or put forward for discussion, require the practitioner to apply weightings to criteria as a means of assisting the decision process (Janssens,1990; Hawwash, 1991A; C.I.C., 1994). Such efforts to obtain an objective output rely to a greater extent on a subjective input! Those practitioners who *have* developed quantitative methodologies are keeping this information in-house. By not allowing advances in technique to be universally known the industry cannot benefit as a whole.

Russell and Skibniewski (1988) highlighted the difficulty of quantitative analysis, by including the following in their list of 'problems' for construction owners; "the difficulty of developing, implementing and evaluating objective contractor prequalification criteria for a given project circumstance that allow accurate, sound and consistent decisions to be made (and the) difficulty of formalising the decision making process without introducing subjective judgment and biases."

Although an absolute quantitative analysis is desirous for any selection (decision) task, this is not always attainable because;

a) the nature of the exercise revolves around and is dependent upon the 'human factor', "It is people who take decisions -not techniques" (Mott, 1992);
b) the cost to the user of obtaining ' perfect' information for use in the process is too high and would render the process impractical (see chapter 5). This impractical solution would lead to rejection by those it is designed to help.

Due to the nature of this selection task, any model designed as an alternative will therefore need to be hybrid, in the context of quantitative and qualitative composition. However, an alternative proposal should as far as practically possible inherently objective.

3.3. SUMMARY

Unlike a typical consumer, the construction client is not usually afforded the luxury of more usual methods of product appraisal (eg., comparison), before commitment to purchase.

Hence, once committed to acquisition the success or otherwise of the construction process determines the level of satisfaction achieved from the overall exercise by the client.

Client's superlative requirements in terms of time, cost and quality are not mutually exclusive. Good quality *can* be achieved at reasonable cost and in good time.

Therefore, selection must encompass evaluation of candidate contractors in terms of their potential to achieve these superlative requirements.

Current selection practice is beset with shortcomings. These may be grouped in terms of four main areas of weakness, namely;

a) lack of a standard, rationalised, universal approach to the selection task;
b) too much long term confidence reposed in contractors and attributed to prequalification;
c) an over reliance on bid value during tenderer evaluation and final selection;
d) an abundance of and reliance upon, subjective information and analyses.

These weaknesses not only justify the need for some revision of existing practice but moreover, the remedial measures advocated will help serve as a basis for the design of an alternative selection method.

In the final analysis, any alternative selection model must attempt to make good the failings identified. After all, the prime purpose of performing such identification was to ensure that a replacement is superior to it's predecessor.

CHAPTER 4

THE ESSENCE OF SELECTION: DISCRIMINATING CRITERIA

4.0. INTRODUCTION

Fundamental to the act of selecting anything (particularly where a choice is available), is the need to compare the potential acquisition in relation to a range of standards or expectations (selection criteria). This philosophy equally applies to the selection of a contractor. Hence, it was established at an early stage of the research that the new selection model would be founded on this principle of comparison / predetermined standards. This meant it was necessary to determine criteria essential for inclusion in the model, along with their relative levels of importance to the contractor selection process. The objective was accomplished in two stages;

a) by literature review;
b) by structured questionnaire survey of construction owners and selection practitioners.

This chapter describes this two stage process, culminating in a list of essential discriminating criteria, respectively weighted and ranked in terms of importance.

4.1. THE LITERATURE REVIEW

A thorough literature review ran concurrently with this research, observing all facets of contractor selection and tendering practice. However, in the specific context of *discriminating criteria* the prime aims of perusing the literature were;

a) to identify those criteria[1] considered by authors and commentators as

[1] In this context a criterion is a characteristic against which a contractor may be investigated.

necessary for consideration when selecting a contractor;

b) to identify the attributes[2] considered worthy of investigation to evaluate the performance potential[3] of contractors;

c) to utilise (a) and (b) for the purpose of compiling a structured questionnaire, for presentation to selection practitioners and construction clients for deeper investigation.

The early reports referred to in Chapter 2 (Simon, 1944; Banwell, 1964; BEDC, 1967; NEDO, 1968) were none too specific regarding contractor selection criteria. Rather, the guidance they offered was very general (what one might describe as procedural in nature), simply indicating the need to prequalify contractors in order that subsequent lowest bid may be 'confidently' accepted. Further ordinary advice was given; "contractors should be familiar with the proposed work".

In short, other than promoting prequalification and recommending experienced firms, their scope was limited. It seems that at about this time, selection criteria employed were chosen at the complete discretion of the client or, client advisors.

Smit (1978) wrote with specific reference to the National Transport Commission of South Africa and suggested that contractors should firstly be scrutinised for their *technical competence*. It was intimated that standard criteria should be established by the client, around which all contractors could equally compile their bid. These criteria could be made known to contractors in tender documents by supplying tenderers: a critical path network to enable the tenderer to follow the logic of the proposed construction and, a technical report reflecting any other pertinent information. 'Satisfactory' tenders subsequently received (ie., those complying with the standard criteria) should then be evaluated on financial grounds specifically exploiting;

[2] In this context an attribute is a characteristic of a contractor that may be measured.

[3] In terms of achieving satisfactory project performance.

- *The use of the 'S' curve* -to depict the anticipated cumulative cashflow commitment required of the client for each given contractor;
- *The discounted cashflow technique* -to obtain a more meaningful financial comparison of submissions.

(Obviously to perform either of these functions the contractor would need to indicate anticipated contract programme and magnitude of payments).

Smit pointed out a fundamental difficulty of such financial analyses -deciding the rate of discount to be applied. One option would be to use the 'opportunity cost' of capital for the client as a guideline ie., the project must earn at least a predetermined return compared with other projects or investments. One was also reminded that the advantages of shorter contract periods should not be overlooked, particularly where price escalation (inflationary fluctuations) might prevail. Smit exhibited an obvious bias towards evaluating the financial implications of tender submissions, rather than evaluation of the contractors themselves. Financial analysis is prudent but such an approach could be suspect if the latter becomes subservient to the former. It is also interesting that Smit advocated what could be described as a qualification component *within* the tender process. That is, only those contractors satisfying the 'standard' criteria went on to be further considered in financial terms.

A guidance document titled "Contractor Selection -a guide to good practice" was issued by the estimating service of the Institute of Building (I.O.B.1979). Therein, selecting a contractor was boldly defined as a two stage process: i) preselection and ii) selection. It was suggested that the client or client advisors must establish the financial stability of contractors, along with their ability to carry out and complete the proposed project in accordance with the design and programme requirements. In a sample prequalification questionnaire they recommended that the contractor should provide details of;

- *The firm* -registration number / details of parent company if applicable and whether the parent company guarantees performance of it's subsidiary?
- *Share portfolio* -nominal and paid up capital
- *Insurance* details
- *Turnover history* -details for the last five years
- *Experience* -details of contracts carried out within the last five years; description / client / architect / value and contract period
- *Employee details* -regular administration, technical and operatives
- *Sub-contract details* -those work elements normally subcontracted
- *Referees* -three references (type not indicated).

The five year retrospective investigation (turnover and experience) is very thorough but might penalise younger companies. The I.O.B. recommendations focus much attention on what *tendering method* to use, be it negotiation, or competition, but more specific information such as contractor evaluation methods are not discussed.

Diekmann's work (1979) was directed towards the selection of cost-plus contractors[4] in the U.S.A. Diekmann postulated that prequalification of contractors should be based upon;

- *Previous experience*
- *Previous defaults*
- *Current workload*
- *Experience of key personnel*
- *Financial conditions of the company.*

It was explained; "Ultimate project success depends more upon the skill, reputation and experience of the contractor rather than the price charged for his services.

[4] Cost plus is a contractual arrangement whereby the contractor is remunerated for all costs incurred, plus a fee, which is normally a percentage mark-up (hence the more usual description of cost-plus-fee). The method is unfavoured in the U.K. because of a lack of accountability on the part of the contractor but it is often used where the extent of the work is difficult to predetermine, such as maintenance and emergency jobs.

However, it is recognised that measuring skill, reputation and experience of a potential contractor is a difficult task for it involves not only uncertainty, but more significantly, an exceptionally large number of disparate dimensions. It is correct that contractor attributes should take precedence over cost but Diekmann confirmed the difficulty encountered when attempting to measure them. This recognition may be the fundamental reason why most authors decline to suggest methods of criteria assessment.

Selecting a management contractor for the public sector was discussed in a document produced by Bovis (1981). They suggested that assessment should be carried out by the design team *and* the client, based upon the following criteria;

- *Ability of the contractor to integrate* -anticipated compatibility of the contractor with the design team
- *General approach towards the project* -an appreciation of potential problems
- *Project team experience* -more general and technical competence
- *Contractors experience* -projects of a similar nature and extent of local knowledge
- *Contractors organisation* -financial stability, current workload and resources available for the given project
- *Contractors standard procedures regarding control* -time, cost and quality: with particular reference to subcontractors.

Finally, an evaluation of the contractors costs and proposed programme period should be conducted for the specific project. Obviously, such measures (tender sum financial analysis / programme period) may only be applied to tender submissions and may therefore be classified as secondary investigative. That is, the former be applied to all contractors desirous to tender whilst the latter be applicable only to tenderers.

The Institution of Civil Engineers guidance notes on tender procedure (I.C.E., 1981) state that prequalification is 'normally' required and, that this should initially investigate companies in view of their *relevant experience* to the type of work proposed, in the location or circumstances applying. Specifically, prequalification should investigate;

- *Financial standing* -that the firm is financially stable and / or has guaranteed backing of a larger group, this should encompass examination of external reports and bank reference(s)
- *Technical / Organisational ability* -that adequate capacity and ability is available to undertake the works at the time in question. Enquiries may be made to other employers in respect of their past experience(s) with the contractor. This will further facilitate;
- *General experience / performance record* -that the firm has had sufficient experience in the type and magnitude of the works proposed
- *Satisfactory performance reputation.*

It is prudent advice to investigate a contractors resource capacity "to undertake the works *at the time in question*" -adequate resources (financial, managerial, plant etc.) are irrelevant to the client if they are to be committed to other projects. However, contrary to advice offered from other sources, the I.C.E. state that "Contractors whose qualifications and past performance records are already well known should not be required to prequalify on every occasion". The writer contends that this is extreme folly for the reasons described in chapter 3 (3.2.2.). Up-to-date prequalification information is an essential ingredient of judicious selection.

Peters (1981) broadly categorised the selection process as consisting of two components. The first should revolve around past experience / performance taking account of;

- *Technical competence*

- *Management expertise*
- *Attitude to safety*
- *Attitude / willingness to correct faulty / incomplete work*
- *Ability to meet programme*
- *Claims consciousness.*

Equal importance is attributed to 'more general' factors but an element of overlap does seem apparent;

- *Perception / understanding of the proposed project*
- *Soundness of approach* (secondary investigative criterion)
- *Contractors own specific work experience*
- *Qualification of management.*

As highlighted in Chapter 2, F.I.D.I.C. (1982) advocate a systematic approach to the subject of obtaining and evaluating tenders. They have produced a standard form of prequalification (ibid, pp 28-31). The information requested from firms includes;

- *Structure and organisation* -associate company(ies), parent company details where applicable and a hierarchal flow chart of company management structure
- *Joint venture* -general details and bankers where applicable
- *Financial statement* -authorised / issued share capital, turnover history, value of current workload and copies of the three previous trading years accounts
- *Resources;*
    - *personnel:* number of technical / administrative staff and a list of executive directors
    - *key personnel:* major works experience, years with company / number of years within construction.
    - *plant:* i) contractors perception of the main plant requirements for the

proposed project and ii) plant acquisition policy

- *other:* subcontractor details and offsite fabrication facilities

- *Experience;*
    - *geographical:* countries / country of proposed project
    - *relevant projects completed:* performance details for last six years
    - *all work in progress:* project details and anticipated completion dates.

F.I.D.I.C. place importance in a contractors management. Also, resources available, in particular, projected workload capacity. Their prequalification questionnaire is very comprehensive without being too large in comparison to others uncovered in this research.

Horgan (1984) concentrated on the civil engineering sector. He commends the use of a select list made up entirely of prequalified contractors and proposes the following as essential prequalification criteria;

- *Type of company* -private, exempt private, public, limited liability, partnership
- *Capital* -authorised and issued
- *Debentures and loans* -value and date of maturity where applicable
- *Bankers* -name and branch
- *Associated companies* -parent / associate / technical liaison etc.
- *Experience* -type of work able to be undertaken by the contractor
- *Turnover* -history for the last three years
- *Catchment* -usual geographic areas of operation
- *Employees* -average number employed over the last three years within technical, management, contract administration and design
- *Qualifications* -an indication of who in management / administration are engineering graduates
- *Qualifications* -an indication of who in management / administration are

members of recognised engineering institutions

- *Construction plant* -major categories owned / available for the proposed work
- *Recent experience* -contract period, contract value, name, employer and location for three previous projects
- *Trade associations* -to which the company belongs.

Horgan goes on to suggest that an initial invitation to tender list may be compiled by the application of 'logical' criteria. Typically, firms should be eliminated;

- Who's *annual turnover* is less than £x (an amount deemed appropriate to handle the contract size concerned)
- With no *previous experience* of a similar project in terms of size and technical requirements
- Not having offices *in the locality* of the site
- With *low issued capital* or, depending on an associate or parent firm for finance or credit.

Finally, further pruning may be considered using what Horgan terms 'preference' criteria. For instance, does the select list contain firms;

- To whom the *employer has a duty* or other benefit eg., reciprocal trading
- Who have a good reputation for *labour relations*
- For whom the employer has a *predilection.*

It would seem that Horgan's approach is somewhat dependent upon the number of contractors wishing to prequalify eg., a two stage select list elimination process would seem unnecessary where the number of firms expressing a desire to tender was limited. Nonetheless, the philosophy is sensible where the opposite applies. It does seem that civil engineering guidance documents attribute more importance to a prequalification exercise than do building sector documents.

Baker & Orsaah (1985) postulated that selection is a decision making process who's criteria are determined by the customer (client) and that therefore, determining the customers needs is a positive step by the contractor towards successful award of a competitive contract. They found that price was beyond doubt the most influential factor for clients, but also considered was;

- *The financial position of the company*
- *Company reputation*
- *Ability to complete on time*
- *Clients prior business relationship with the contractor.*

A summary of their findings, both from the standpoint of the client and the contractor, is given in Tables 4.1. and 4.2. respectively.

Table 4.1.
Perceived importance of selection criteria -construction clients

		Survey response %	
Criterion	Rank	Most influential	Least influential
Low price	1	86.8	2.4
Company financial standing	2	68.7	9.6
Company reputation	3	51.8	15.6
Early completion date	4	45.8	31.4
Prior relationship	5	36.1	30.2
Consultant's recommendation	6	20.8	53.6
Trade Union record	7	7.2	72.6
Company negotiating skill	8	7.2	77.2
Company proximity	9	4.8	54.2
Company informal contacts	10	4.8	75.9
Company nationality	11	4.8	77.2

Example: 86.8% of clients rank low price most influential in the awarding of contracts with only 2.4% considering this same variable least influential. 68.7% rank company financial standing second and so on.

Table 4.2
Perceived importance of selection criteria -contractors

		Survey response %	
Criterion	Rank	Most influential	Least influential
Low price	1	84.0	-
Company reputation	2	62.4	2.2
Prior business relationship	3	39.8	16.2
Early completion date	4	37.6	26.9
Financial standing	5	31.5	12.0
Company negotiating skills	6	20.9	38.5
Company informal contacts	7	13.3	36.7
Company proximity	8	7.7	57.0
Trade union record	9	7.8	62.9
Company nationality	10	1.1	79.1
Company advertisements	11	1.1	90.1

Adapted from Baker & Orsaah (1985)

They direct a comment towards contractors; "It is important of the firm to be mindful of the fact that successful selling in construction contracts is not only the winning of the contract but the successful completing on time, at the required standard and to budget". This implies that clients place some emphasis on past performance and prior relationship(s) with contractor companies.

Birrell (1988), proposed his appraisal on "the quantified past performances" of contractors. He quotes the following criteria as essential for investigation;

- *Overall performance*
- *Management* -quality of site staff
- *Management* -quality of craft supervision
- *Communication* -interaction with home office
- *Quality of safety*

- *Efficiency* -use of labour, equipment and materials
- *Effectiveness* -cost management / time
- *Claims* -by and against contractor
- *Communication and character* -interface with clients, other contractors, local construction industry and third parties
- *Labour relations.*

In an attempt at quantifying the importance of each selection criterion Birrell assigned each a weight, which was based on a number of observed contractor evaluation forms (twenty in total). The evaluation forms were those used by project owners from various power and industrial companies to evaluate and store the performance record of their construction contractors. This number was subsequently expressed as a percentage and these findings may be observed below. However, because the results are a function of research conducted in the U.S.A. it should be borne in mind that bias / preference may be different in the U.K;

- *Overview of contractor (18%)*
    - Contractor capability -reliability and financial capabilities to complete the project to the owners requirements
    - Overall performance -management skills, problem anticipation and administrative efficiency
- *On-site Management (22%)*
    - Site staff -supervision, decision making and technical ability
    - Craft supervision -efficiency of gang sizes, motivation, programmes and interfacing with regulations
    - Interface with home office -supervision of home office staff working on project, frequency and effect of their site visits
    - Quality of safety
- *Resource flows and productivity (29%)*
    - Labour and it's use -technical ability, workmanship, productivity,

absenteeism etc.

- Equipment and it's use -availability and use of appropriate equipment, working condition and quality of maintenance
- Materials flow -appropriate quality, efficiency of procurement, delivery processes

- *Management of costs and time (21%)*
  - Cost management -quality of control system, handling of billings and payments from contractor
  - Time management -time planning skills, ability to complete on schedule
  - Claims by and against contractor -reasonableness in filing for extras, ability to settle
- *Interface of contractor with others (10%)*
  - Owners and agents -quality and quantity of written and verbal information
  - Other contractors -effectiveness of management of subcontractors
  - Local construction industry -relationships with local trades and suppliers
  - Labour relations -sources of labour and labour on site
  - Third parties -compliance with government agencies, handling of permits and general public around site.

As discussed in Chapter 3, Rowlinson (1988) found that procurement path was no predictor of performance but rather, that management actions coupled with contractor organisation and contextual variables have a much stronger influence on successful project outcomes. The main factors promoting performance were found by Rowlinson to be;

- *Good management decisions* -co-ordination, control and monitoring
- *Client* -timely decisions
- *Client* -sophisticated (familiar with the construction process)
- *Compatibility* -organisation and procurement form

- *Experienced* -contractor
- *Communications* -a good flow within the project coalition
- *Early involvement of the contractor* (package deals or two stage tenders).

A negotiated selection method, a payment system which ensures good cashflow for the contractor, an equal distribution of risk and a compatible contractor / client structure, were also conducive to good performance.

Russell & Skibniewski (1988) looked specifically at contractor prequalification in the U.S.A. They pointed out that many American organisations and construction owners have developed their own prequalification questionnaires (eg., American Institute of Architects form: AIA 305; American Association of General Contractors standard form: No' 40). Typically, these forms seek information from the contractor in respect of;

- *Company organisation* -type of ownership, name(s) of principals
- *Current balance sheet* -(financial standing)
- *Listing of current projects under construction* -(experience / current workload)
- *References;*
    - *Bank*; does the contractor have a relationship with a bank that in the event of cashflow difficulties, would facilitate the required financing?
    - *Trades*; does the contractor promptly pay bills on time and what is his reputation?
    - *Insurance*; does the firm have adequate cover and what are the frequency of claims?
    - *Previous clients*; what are general levels of satisfaction with work previously performed?

They point out that due to 'outside partners' having their own biases, references drawn on a contractor should be assessed cautiously. Furthermore, it is highlighted that contractors might only list references that they feel will give a favourable rating. Consequently, it is suggested that some advantage will be accrued during prequalification by approaching sources of reference not listed such as;

- *Credit rating services*
- *Visits to the contractors home office and sites of operation.*

Merna & Smith (1990) found that most public sector clients in the U.K. applied some form of prequalification regime when selecting contractors. They define the prime purpose of prequalification to be; "so as clients may obtain bids that are reasonable and easy to evaluate, by equally suitable and experienced contractors". The criteria most commonly addressed were;

- *Financial stability*
- *Managerial capability*
- *Organisational structure*
- *Technical expertise*
- *Experience of comparable construction.*

In instances where an extensive number of contractors had applied to prequalify then 'initial criteria' could be applied to narrow down the applicants into a short list (mirroring Horgan earlier). Initial criteria included;

- *Regional and physical locations* (in respect of the proposed project)
- *Technical / managerial expertise*
- *Type and size of the proposed contract* (in respect of contractors reputation).

Traditionally, this short list is one-and-a-half times the number of contractors to be invited to tender. Merna and Smith also pointed out that this narrowing down process is usually performed on a subjective informal basis. This seems incompatible with the significance of the decision being taken; "there is a danger that the contractor most likely to offer the optimum bid might be rejected at this stage" (ibid). To choose tenderers, short lists are then generally subjected to a more detailed investigation to ascertain the extent of contractor's;

- *Financial standing;*
    - financial statements (accounts)
    - financial exposure -domestic and overseas contracts (workload)
- *Technical ability;*
    - commitment of labour/plant
    - ability towards required type, size and quality of the project proposed
    - ability to perform on site (past performance)
- *Managerial organisation;*
    - approach to risk
    - contract strategy (planning)
    - claims consciousness.

In contrast to the I.C.E. (1981) document reviewed earlier, Merna and Smith affirm that even if a contractor has previously prequalified (for this client) this information should be reassessed (ie., prequalification per project).

With regard evaluation of tender submissions they found that assessment is based largely on the bill of quantities although many clients rely increasingly on the submission of non-contractual information to try and identify likely performance. Several clients indicated the significance of timely completion of tender but, the writer questions how such can be applicable -if a deadline for tenders is set then either contractors do, or do not achieve it?

Schleifer (1990) identified the incipient causes of business failure in the construction industry. It was found that the five most common causes of failure were;

- *Resource capacity* -a drain on resources due to an unforeseeable increase in project size
- *Geographical experience* -unfamiliarity of new areas of operation
- *Experience* -tackling new unexperienced types of construction
- *Management resource* -changes of key personnel and a lack of managerial maturity in expanding organisations
- *Organisational structure* -problems due to poor accountancy systems and the failure to evaluate project feasibility.

This would indicate it prudent to consider contractors in terms of i) normal size of projects undertaken, ii) experience within the geographical area of the project, iii) experience of the specific project work types, iv) turnover of senior management, v) qualification of senior management / company owners.

Hawwash (1991) indicated two stages at which the client can control the selection of contractors. Firstly, before the issue of tender documents (prequalification) to ensure that contractors are;

- *Reputable*
- *Acceptable to the client*
- *Capable of undertaking the work* -type, and value of contract.

Secondly, before contract award (tender evaluation) the client should ensure that;

- *The contractor has fully understood the contract*
- *The firms bid is realistic* (see Merna & Smith, 1990 re: suicidally low and misconceived bids).

Information required of the contractor during prequalification should include;

- *Details of similar work undertaken* (experience)
- *Financial data on number / value of current contracts* (current workload)

- *Turnover history / Banking institutions* (financial stability)
- *Management structure* -particularly key personnel details.

Regarding tender evaluation, Hawwash placed particular emphasis on the financial ramifications of bids, identifying the following variables as amenable to financial quantification;

- *Duration of construction* -contractors should specify the preferred duration (where applicable) and the client should take account of benefits or burdens obtained therefrom
- *Magnitude of payments* -where applicable mobilisation and advance payments should be specified
- *Expected pattern of payments* -an expected schedule of payments for measured work should be submitted
- *Price inflation* -where a contract price adjustment clause is included (fluctuations clause) the probable effects of price inflation on different bids should be compared.

A single financial parameter was defined to represent these variables; "The successful bid should require the lowest Net Present Value of payments from the client, at a discount rate specified by the client". This emphasis on financial analysis of submissions is similar to the philosophy of Smit earlier.

Griffiths (1992) offered valuable guidance regarding the client / contractor relationship at early procurement stage. Initially, he confirmed the prime failing of current selection practice which is also the fundamental premise upon which this research is based; "client choice is (currently) based upon qualitative rather than quantitative interpretation of the contractors credentials".

Griffiths recommends evaluation of the following contractor attributes;

- *Organisational framework* -structure and management
- *Adequate resources* -ability to deploy and manage resources combined with a sound financial base
- *Contractors proposals* -how do they compare in relation to other tenderers? (only applicable once tenders have been submitted).

He goes on to attach further detail to these initial areas of investigation;

- *Contractors reputation* -this should exhibit a proven record of reliability, effectiveness and success in the sphere of potential employment
- *Local or National reputation* -a positive reference from past clients is favourable and appraisal of the quality of completed work by site visits, should be established
- *Financial stability* -should be observed particularly the length of time in business, balance sheet analysis, the value of projects normally undertaken and current anticipated future commitments. This may be combined along with financial references from funding institutions
- *Resources* -must be considered;
    - *physical:* (offices, plant, equipment, stores etc.)
    - *financial:* (cashflow and liquid assets)
    - *personnel:* (skills available and general ability)
    - *management:* (skills in the technical area needed to carry out the works).

Griffiths includes risk apportionment amongst essential selection criteria. However the writer contends that this is more a matter of contractual arrangement not contractor selection (refer Chapter 3). An exception to this statement would exist where the contract form is not common to all tenderers (eg., negotiated agreement between the employer and successful contractor), but the array of standard construction contract forms available, even for works of a limited size make negotiated agreements seem superfluous and outdated.

The National Joint Consultative Committee (N.J.C.C. various) offer wide ranging Codes of Procedure for the building sector eg., Code of Procedure for Single Stage Selective Tendering (1989), Code of Procedure for Selective Tendering for Design and Build (1985). The codes recommend that a short list of suitable tenderers should be drawn up from the employers own list (will apply where a continuous build programme exists) or an ad-hoc list of contractors of established skill, integrity, responsibility and proven competence for the work of the character and size contemplated. The Codes only suggest succinct guidance concerning selection criteria viz;

- *Financial* -standing and record
- *Experience* -recent and general
- *Reputation*
- *Management* -adequate structure
- *Capacity* -adequate (overtrading).

The N.J.C.C. further recommend that the number of tenderers invited should be limited to a maximum of six and that; "the object of selection is to make a list of firms any one of which could be entrusted with the job". Notwithstanding this, counsel is not given as to how such evaluation should be performed. This is mildly surprising in that the N.J.C.C. codes are generally perceived as the predominant tender guidance documents within the building sector.

Finally and despite rationale to the contrary offered elsewhere, (Diekmann, 1979; Birrell, 1988; Merna, Smith, 1990; Griffith, 1992) the N.J.C.C. state; "If this (prequalification) is achieved then the final choice of contractor will be simple; the firm offering the lowest price. Only the most exceptional cases justify departure from this recommendation". Unfortunately, this promotes a reliance upon tender sum as final selection criterion (refer Chapter 3, section 3.2.3.).

Russell et. al. (1992) conducted a survey amongst public / private sector construction owners and managers in the U.S.A. They established that the following factors had most impact on practitioners when conducting prequalification;

- *Financial stability*
- *Experience*
- *Failure to have completed a contract*
- *Quality achieved*
- *Key personnel*
- *Past performance* -time overruns
- *Willingness* -to resolve conflict and problems.

Conversely, factors with the lowest impact included;

- *Type of company ownership*
- *Location of home office* -relative to jobsite
- *Equipment resources*
- *Employment trends.*

Notwithstanding the American bias, in its entirety the work serves as an excellent point of reference regarding selection criteria. From the results of their research the authors conclude that the variables; *past performance* (time, cost, quality), *experience*, and *key personnel* (availability and experience) have particular significance on the prequalification process.

Sanvido et. al. (1992) concluded that there are four major factors influencing construction project success, in terms of satisfied expectations for the participants including the client;

- *Team* -should be well organised with common goals
- *Contracts* -should avoid conflicting interests and equally apportion risk /

reward

- *Experience* -of the contractor is important particularly management, planning, design, types of construction and similar projects
- *Communications* -should be timely and contain optimum information from all members of the project coalition throughout.

Tam (1992) investigated the performance potential of contractors in Hong Kong. En-route to formulating his discriminant analysis model his literature review revealed the following attributes as most relevant to a contractors' successful project implementation;

- *Performance* -past / previous
- *Performance* -potential
- *Managerial* -expertise
- *Capacity* -current workload
- *Experience* -project specific
- *Quality control* -programme
- *Claims* -consciousness
- *Market position* -and reputation.

Of these, *past performance*, *reputation* and *experience* emerged with most prominence in his resulting equation.

Janssens (1992), dealt specifically with the design and build (D&B) procurement option and offered comprehensive advice regarding contractor selection. Janssens pointed out that under the D&B method the client "puts all eggs in one basket" by entrusting both pre-contract design *and* production to just one contractor. Therefore selection takes on more importance than under the more traditional methods of procurement because should the contractor fail, then client problems are potentially twofold.

A two stage process of selection is recommended; initial questionnaire elimination followed by secondary questionnaire / interview. First stage elimination criteria are suggested as being;

- *Experience* -turnover; last year and estimated this year (the writer contends that turnover is more a measure of volume or output whilst experience is better measured in terms of size, number of projects completed etc.)
- *References* -for projects completed within the last twelve months
- *Other* -latest annual company accounts and reports, pre-printed company brochures and those of external consultants if appropriate.

Rather uniquely, the possibility of asking the contractor to sign a declaration that his bid will be bona-fide if selected to tender, is also suggested. After prequalifying contractors secondary investigation is recommended in the form of interviews. The use of a questionnaire to lay down the interview agenda is advocated. The questionnaire should set out to investigate;

- *Company size* -that the size of the proposed project is not disproportionate to turnover or normal size of project encountered by the contractor
- *Experience of similar construction* -in terms of work; nature, scope and size
- *Design experience* -where the contractor undertakes design in-house
- *Location of project* -that contractor knows the area of the project well
- *Available resources* -by analysis of current workload and orders anticipated.

A broader description of Janssens' elimination technique is discussed later in chapter 5.

A comprehensive prequalification questionnaire in use by a major international employer (anonymity respected at request of supplying information to writer) concentrates on the following criteria;

- *Organisational* -joint venture / parent company details where applicable, management structure, company membership of associations, corporate relationships

- *Ownership of the company* -details of any substantial changes in the last five years, top five voting shareholders, those individuals holding more than 2.5% of total share issue
- *Financial* -summary of accounts for last three years, main bankers, maximum value of contracts for which 10 percent performance bond may be obtained
- *Experience;* i) previous projects; outstanding claims, permission to approach employer for reference, ii) specific work types; details of contracts executed in the last three years
- *Current workload* -details and permission to approach employer/s
- *Anticipated future workload* -start / completion dates, value and description
- *Anticipated future capital investments* -land, property, plant etc.
- *Resources;*
    - *Planning* -systems available
    - *Design* -facilities able to be called upon
    - *Fabrication* -offsite facilities
    - *Plant* -perception of requirements/procurement methods
- *Miscellaneous* -safety, industrial relations, quality assurance, safety officers, company safety policy, and insurance details.

This is amongst the most comprehensive of the prequalification questionnaires uncovered during this study. The contents mirror guidance offered within the F.I.D.I.C. (1982) document. The extensive regime underlines the potential adverse implications of employing a poor contractor on major contracts: as undertaken by this client.

Public sector qualification select list questionnaires (anonymity as per above) have exhibited the following characteristics regarding criteria investigated;

- *Organisational structure* -age, nature of business, ownership, insurance cover, turnover history
- *Experience* -work types, maximum value of contracts, references
- *Employee structure* -administrative, technical, labour
- *Training regime* -span of control
- *Subcontractor policy*
- *Membership of trade associations*
- *Equal opportunities policy*
- *References.*

A wide amount of variation has been observed in the structure and make up of public sector prequalification questionnaires -this correlates with the findings of Merna and Smith (1990).

The Construction Industry Council have published guidelines on the value assessment of tenders (C.I.C., 1994). They advocate the use of a questionnaire to be included with tender documentation, to collate information on 'key' value assessment areas. Discretionary weighting ranges for these quality assessment criteria are further suggested and an overview of both these aspects is exhibited in Figure 4.1.

The quality weightings used in a final analysis are ultimately decided by the practitioner. When summed they should equal 100%. This 'quality' component is then carried forward to a final assessment, where *overall* weightings (assigned to both cost and quality) should have been predetermined in line with nature of the project under scrutiny. (Refer section 3.1.2. and Table 3.4., Chapter 3).

Figure 4.1.
Value assessment criteria and suggested weightings

CONTRACTOR OR CONSULTANT

Weighting range: 20% to 30%

Financial status, insurance, quality assurance, enthusiasm, resources, I.T., reputation, experience (size, scope, nature of project), references.

PROJECT ORGANISATION

Weighting range: 15% to 25%

Project team, authority of team members, logistics (location to site, client, consultants), planning and programming expertise.

KEY PERSONNEL

Weighting range: 30% to 40%

Qualifications, understanding of project objectives, flair and commitment, compatibility, communication skills, references.

PROJECT EXECUTION

Weighting range: 20% to 30%

Programme, method and approach, management control procedures, resources to be applied to project, health and safety matters.

After C.I.C. (1994).
$\sum$ Discretionary weightings = 100%

4.1.1. Summary of the literature search

By way of a starting point in attempting to understand the relevance of the criteria discussed, they were collated into groups of like nature viz;

Organisational criteria -criteria concerned with corporate structure / organisation / policy

Past experience criteria -being those criteria which establish what activity the firm has previously been involved with

Past performance criteria -being ways of establishing how well such involvement was executed

Financial -primarily concerned with corporate stability / trading capacity

Other criteria -for those which at this stage appeared to fit nowhere in particular.

These groupings are shown in tables 4.3 to 4.7. It can also be seen that each criterion has been assigned a *rating*. This was ascertained by observing the number of times that the authors discussed above, commended each criterion as necessary for consideration when selecting a contractor (cf. Birrell, 1988).

Table 4.3. Organisational Criteria

n	Criterion.	Rating	Sub-rank	O'all rank
1.	Structure of organisation	7	1.5	6
2.	Qualification of key persons	7	1.5	6
3.	Resources non-specific	6	3	8.5
4.	Ownership of company	5	4.5	12
5.	Management Structure	5	4.5	12
6.	Insurance cover	4	7.5	19
7.	General reputation	4	7.5	19
8.	Plant acquisition policy	4	7.5	19
9.	Number employees/trends	4	7.5	19
10.	Sub contractor policy	3	11.5	27.5
11.	Assoc' Co'/joint venture details	3	11.5	27.5
12.	Co' membership - trade organisations	3	11.5	27.5
13.	Health & Safety policy	3	11.5	27.5
14.	Area of catchment	2	14.5	35.5
15.	Fabrication facilities	2	14.5	35.5
16.	Parent Co' details	1	18.5	44.5
17.	Risk attitude	1	18.5	44.5
18.	Nationality	1	18.5	44.5
19.	Training regime	1	18.5	44.5
20.	Key persons: corporate membership	1	18.5	44.5
21.	Equal opportunities policy	1	18.5	44.5

Table 4.4. Past performance Criteria

n	Criterion.	Rating	Sub-rank	O'all rank
1.	Performance non-specific	5	2	12
2.	Technical competence	5	2	12
3.	References - past clients	5	2	12
4.	Quality control record	4	4.5	19
5.	Claims consciousness	4	4.5	19
6.	Time overruns	3	6	27.5
7.	General attitude	2	7.5	35.5
8.	References non-specific	2	7.5	35.5
9.	Labour relations	1	10.5	44.5
10.	Willingness to resolve problems	1	10.5	44.5
11.	Prior relationship with client	1	10.5	44.5
12.	Non-completion of a contract	1	10.5	44.5

Table 4.5. Past experience Criteria

n	Criterion.	Rating	Sub-rank	O'all rank
1.	Experience non-specific	9	2	3
2.	Type of contracts completed	9	2	3
3.	Size of contracts completed	9	2	3
4.	Experience of key personnel	3	4	27.5
5.	Contractors design experience	2	5.5	35.5
6.	Geographic experience	2	5.5	35.5

Table 4.6. Financial Criteria

n	Criterion.	Rating	Sub-rank	O'all rank
1.	Analysis non-specific	10	1	1
2.	Current workload	7	2	6
3.	Turnover history	6	3	8.5
4.	Anticipated cashflow	4	4.5	19
5.	Share portfolio	4	4.5	19
6.	Analysis - financial statements	3	6	27.5
7.	Bank references	2	7	35.5

Table 4.7. Other Criteria

n	Criterion.	Rating	Sub-rank	O'all rank
1.	Location of office to project	4	1	19
2.	Understanding of proposed project	3	2	27.5
3.	Third party recommendation	2	3	35.5

Based on this rating, sub-ranks were established, these being ranks amongst criteria within the generic group (hereafter designated a factor eg., the factor organisational criteria). Overall ranks were also established, these being ranks amongst all the criteria considered (hereafter the term variable is also used in the context of a synonym for a criterion). Where ties exist then the rank was calculated by assigning the tied criteria the mean of the ranks they occupy (Freund & Simon, 1992).

All rankings were checked using the formula: $N(N+1)/2 = R_n$ where N = total number of scores ranked and R_n = total sum of ranks (Meddis, 1985). Excepting overall rank 1, all other criteria are tied to a greater or lesser degree.

Although indicative to a point, the results of the ranking exercise should be viewed with reservation. This is because the sample size was limited and, because the authors observed had not assigned any quantitative levels of importance to the criteria. Also, authors were not confined to the U.K. so different levels of emphasis will have influenced discussion. For example, a U.S. client may attach importance to the bonding capacity of a firm, whereas a U.K. client might be concerned with a contractors' methods of subcontractor control. That is, cultural and commercial differences make it unlikely that the same levels of importance would pertain.

Because of the subjectivity associated with any general discussion, in this instance regarding the literature search, a national survey of selection practitioners and construction clients was undertaken to *confirm* what criteria should be included in the model and, the levels of importance that should be attached to each. The criteria uncovered during the literature review served as a basis for designing the survey questionnaire.

4.2. THE NATIONAL SURVEY

4.2.1. The research tool

A structured questionnaire was employed in the survey -see Appendix D. This comprised of three sections. Section one consisted of introductory questions for data classification purposes including nature of respondents' business and total value of work awarded over the two previous years. Section two was an intermediate component which sought to establish;

a) the extent of client dependence upon prequalification;
b) the levels of satisfaction amongst practitioners with regard to their own selection methods; and
c) the levels of satisfaction amongst practitioners / clients with respect to contractor performance.

Section 3, the principal section of the questionnaire, was for ranking factors and variables ie., potential prequalification and secondary investigation discriminating criteria. Here the respondents were invited to;

d) delete any variables from those presented that they considered irrelevant, ie. those that *would not* influence their choice of contractor;
e) add further variables not already listed that they considered important ie. those that *would* influence their choice;

f) rank their perception of importance for the suggested variables (and those in (e) above where applicable) on a 3 point scale;
g) indicate the number of times, that any criteria in (f) were judged to have been the cause of their dissatisfaction with contractor's performance during the period.

In view of the general downturn in construction activity prior to the survey it was decided that the period should span the two years prior the survey (1990 -1992).

4.2.2. The pilot survey

A pilot survey was conducted amongst a small sample to test the questionnaire before an industry-wide survey was launched. This confirmed the usefulness of questionnaire format ie., that the data would be comprehensible and that meaningful data analysis would be possible.

4.2.3. The main survey

Following the pilot survey, minor cosmetic refinements were made to the questionnaire, before the main survey was initiated. The main survey sample were made up as shown in Table 4.8.

Table 4.8.
Composition of the survey sample

	Number	Percentage
Project Managers	58	26
Q.S. Practices	50	22
Architectural Practices	11	5
County Councils	12	5
District Councils	94	42
Totals:	225	100%

The underlying aim in composition of this sample, was to achieve a reasonably balanced blend of private and public sector contractor selection practitioners. These were represented as 53 per cent & 47 per cent respectively, being randomly selected from both public / private sector client groupings. Participants were invited from England, Scotland and Wales.

The sample were forwarded a pre-questionnaire letter introducing them to the theme of the research and explaining why they were invited to take part. All were offered the opportunity to notify the writer if they felt they were unsuitable or did not wish to contribute to the survey. No refusals were received prior to mailing the questionnaire.

4.2.4 The Respondents

The response rate may be observed in Table 4.9. A total of 60 questionnaires were returned (26%) of which 6 were unusable in the analysis (not suitably completed) and a further 1 albeit not completed, offered alternative input. The 53 completed questionnaires represented 23 per cent of the original sample population.

Table 4.9.
Survey response

Questionnaires:	Number	Percentage
Returned complete	53	23
Returned incomplete	6	3
Other information offered	1	-
No response	165	73
Totals	225	100%

Table 4.10. analyses the number and value of contracts awarded by the respondents. The total amount of work awarded of £3,327,000,000 represents a significant part of the construction industrys' workload for the two years under consideration. To put it another way, this figure equates to 4,255 contracts worth an *average* value of £782,000 each, awarded by each respondent for the period.

Table 4.10.
Work awarded by respondents for the period

	Total value work £G	Total number contracts	Mean value each contract
Private sector:	2.843	1,113	£2,554,357
Public Sector:	0.484	3,142	£154,042
All Respondents:	**3.327**	**4,255**	**£781,903**

It is also worth mention, that whilst 47 per cent of the sample were public sector clients they were responsible for only 15 per cent of the total *value* of work done. This is because the private sector projects undertaken were much larger. However, public sector clients awarded 70 per cent of the work in terms of the *number of contracts*. Thus the survey encompassed a broad sample of selection practitioners ie., those who have to award a high number of low value jobs and those assigning fewer but higher value (£) projects. Discussion of the survey results later in this chapter further highlights some of the differences between public and private sector clients.

4.2.5. Analysis of the survey data

The prime aim of data analysis, was to establish a weighting index for each variable which would be representative of its significance in the context of selecting a contractor. Such an index may be debated at this stage on the basis that no established scale or datum currently exists for a comparative analysis.

Input to the final weighting index (W) consisted of two elements: the importance response (IR) and the problem frequency response (PR).

4.2.5.1. The importance response (IR)

IR was designed to mirror practitioner's perceived importance of each criterion. This was measured by inviting respondents to rank each variable on a scale of 1 to 3 where: 3 = critical importance, 2 = some importance and 1 = no importance: The latter being the same as deleting a variable (refer 4.2.1. (d)) which was therefore also classified as 1. Using the relative index ranking technique (Olomolaiye, 1987; Kometa et al., 1994) the aggregate importance response for each variable was converted to a level of relative importance via the formula;

$$IR = \sum \frac{\text{variable points score}}{3\ (\text{sample size})}$$

Therefore, a criterion ranked critically important by all respondents would achieve an index of 1.0 with a decline in perceived importance being mirrored by a decline in IR, down to a minimum value of 0.3 { [53 x 1] / [3 x 53] = 0.3}. The resultant (IR) decimal represents a 50 per cent contribution to the final weighting index (W).

4.2.5.2. The problem response (PR)

This is the remaining component of the final index -ensuring that W was symbolic of a given criterions' significance. PR considered how often each criterion was judged to be related to client dissatisfaction with contractor performance.

For instance, lack of on-site control might be attributable to a poor site manager. This could be considered a function of *qualification of key personnel* and / or *formal training regime* (lack of in this case!). Other forms of dissatisfaction may be in terms of contract overruns, non / late compliance with instructions, unsatisfactory quality, equipment breakdowns etc. Ultimate disappointment will often be felt by clients when a contractor becomes insolvent. However, occasionally a client may be glad to be relieved of a contractor!

Respondents indicated the frequency of such dissatisfaction in respect to each criterion on the questionnaire. Hence, the PR influence on W is directly proportional to this *frequency response*. Obviously, not all respondents would have experienced a problem attributable to *every* criterion. Therefore, PR is expressed as a problem frequency, *in relation to the number of contracts awarded by a respondent.* The mean of all such values, amongst all respondents for a given criterion, is it's PR. Table 4.11. illustrates the PR calculation for the variable *size*.

Table 4.11.
Example of PR calculation -for the variable *Size*

n	Respondent	Nr. contracts	No times	Calculation			Decimal
1.	1	100	2	(2 / 100)	=		0.02
2.	4	24	1	(1 / 24)	=		0.04
3.	6	10	6	(6 / 10)	=		0.60
4.	12	250	2	(2 / 11)	=		0.01
5.	13	11	6	(6 / 11)	=		0.55
6.	14	30	30	(30 / 30)	=		1.00
7.	15	65	4	(4 / 65)	=		0.06
8.	16	16	1	(1 / 16)	=		0.06
9.	26	27	1	(1 / 27)	=		0.04
10.	29	40	2	(2 / 40)	=		0.05
11.	38	6	5	(5 / 6)	=		0.83
12.	40	8	2	(2 / 8)	=		0.25
13.	42	10	2	(2 / 10)	=		0.20
14.	49	16	3	(3 / 16)	=		0.13
15.	51	3	1	(1 / 3)	=		0.33
						Total:	4.27

Therefore, mean = 4.27 / 15 = PR = 0.28

4.2.5.3. Consolidation of data into final indices

From the above it can be established that the greater the relative importance ranking the greater is IR value and likewise, the more 'problem potential' a variable exhibits, the greater is PR value. The philosophy behind consolidation of these two elements into a final weighting index (W), is that a variable's overall importance to the selection process is a product of its intrinsic relative importance (IR) and its potential (in terms of a contractor attribute) to create problems for the client (PR). W is therefore a balanced input of IR and PR, attained via the formula; $W = 0.5(IR) + 0.5(PR)$ ie., $0.5(IR+PR)$. A summary of IR / PR values and final weighting indices for all criteria, is given in Table 4.12.

4.2.6. Analysis and discussion of results

Before analysing the variables, it is important to observe the following additional findings of the survey;

4.2.6.1. Levels of satisfaction with contractor performance

Table 4.13. shows that public sector clients appear more content with the overall performance of contractors. However, one must not overlook the fact that some consultant organisations taking part in the survey may well have represented public clients, which would offset this finding somewhat. Since no definition of 'satisfaction' was offered in the questionnaire, it was left to respondent's own perception of its meaning relative to their organisation. Twenty per cent (public) and 5 per cent (private) respondents were *totally* satisfied with contractors performance. More important perhaps, is that 5 per cent of the private sector were totally *dissatisfied*, which suggests that private sector clients seek more stringent performance levels or have higher expectations than their public sector counterparts. Based on the aggregated results only 12.5 per cent were totally satisfied, whilst 1 in 40 were totally dissatisfied. Clearly, any aid to help select *the most suitable* contractor, would improve underlying levels of satisfaction for clients generally.

Table 4.12.
IR / PR values and final weighting indices

	Relative importance (IR)	*Problem response* (PR)	*Weight index* (W)	*Factor rank*	*O'all rank*
PREQUALIFICATION					
FACTOR: Contractors organisation					
-Contractor size	0.74	0.27	**0.501**	4	27
-Contractor age	0.60	0.27	**0.435**	5	29
-Contractor image	0.55	0.26	**0.408**	6	31
-Quality control policy	0.81	0.25	**0.529**	3	26
-Health & safety policy	0.82	0.34	**0.583**	1	20
-Litigation tendency	0.78	0.31	**0.545**	2	24
FACTOR: Financial considerations					
-Ratio analysis of accounts	0.75	0.51	**0.631**	4	18
-Bank reference	0.75	0.58	**0.669**	1	11
-Credit references	0.75	0.51	**0.634**	3	17
-Turnover history	0.72	0.61	**0.667**	2	12.5*
FACTOR: Management resource					
-Qualification of owners	0.60	0.75	**0.676**	3	9
-Qualification of key persons	0.77	0.53	**0.648**	4	15
-Key persons: years with company	0.64	0.76	**0.695**	2	7
-Formal training regime	0.63	1.00	**0.814**	1	3
FACTOR: Past experience					
-Type of projects completed	0.91	0.56	**0.735**	3	6
-Size of projects completed	0.87	0.83	**0.851**	1	2
-National or local catchment	0.68	0.82	**0.748**	2	5
FACTOR: Past performance					
-Failure to complete a contract	0.95	0.41	**0.679**	1	8
-Overruns: time	0.81	0.27	**0.541**	4	25
-Overruns: cost	0.82	0.33	**0.576**	3	21
-Actual quality achieved	0.93	0.40	**0.667**	2	12.5*
SECONDARY INVESTIGATIVE					
FACTOR: Project specific					
-Experience: geographically	0.66	0.16	**0.409**	5	30
-Experience: similar construction	0.84	0.29	**0.564**	2	22
-Plant resource available	0.60	0.38	**0.486**	4	28
-Key persons available	0.79	0.30	**0.547**	3	23
-Qualification: key persons	0.68	0.67	**0.673**	1	10
FACTOR: Other specific					
-Workload: project duration	0.72	1.00	**0.862**	1	1
-Prior relationship with client	0.79	0.52	**0.651**	3	14
-Home office location to project	0.62	0.67	**0.642**	4	16
-Time of year-weather	0.52	1.00	**0.761**	2	4
-Form of contract used	0.64	0.55	**0.596**	5	19

**joint ranking*

Table 4.13.
Respondents: levels of satisfaction

Client group	Totally satisfied	Just satisfied	Totally dissatisfied	Percentage of sample
Public	20%	80%	zero	47%
Private	5%	90%	5%	53%
All respondents	**12.5%**	**85%**	**2.5%**	**100%**

4.2.6.2. Practitioners perception of their own selection methods

To aid insight as to how practitioners perceived the ability of their own selection methods, they were asked to rank it on a scale of 1 to 5 where: 5 = totally effective, 3 = satisfactory, 1 = totally ineffective. Table 4.14. shows that 10 per cent of all practitioners purported to have in place a *totally effective* selection process. Whilst no practitioner admitted to a *totally ineffective* system, 60 per cent believed their method *satisfactory* with only 2 per cent on the 'anything less than satisfactory' side of the scale. These statistics confirm that most organisations believe their contractor selection method to be adequate. However, the results may be biased as one might not expect practitioners to readily recognise or admit failings of their own system. Indeed, from comparison of Tables 4.13 and 4.14. it can be seen that 85 per cent of all respondents are only 'just satisfied' with contractor's performance yet almost all the sample (98 per cent) believe their selection method to be somewhere between 'satisfactory' and 'totally effective'. Surely, the former statistic would be higher if the latter statement were legitimate?

With 5 per cent of public practitioners' perception being 'less than satisfactory' private sector practitioners believe their methods to be slightly more effective than do their public counterparts.

Table 4.14.
Respondents: perceived effectiveness of own selection method

	Scale				
	1 Totally effective	2	3 Satisfactory	4	5 Totally ineffective
Client group					
Public	10%	30%	55%	5%	0%
Private	10%	25%	65%	0%	0%
All	**10%**	**28%**	**60%**	**2%**	**0%**

4.2.6.3. Reliance upon prequalification

The most prominent feature to emanate from Table 4.15. is that after prequalifying a contractor, 63 per cent of construction clients would not investigate the company further before awarding them a contract.

Table 4.15.
Respondents: reliance upon prequalification

	Yes †	No ††	Total
Private	55%	45%	100%
Public	70%	30%	100%
All	**62.5%**	**37.5%**	**100%**

† *Proportion of owners who would award to contractor who has satisfied prequalification factors*

†† *Proportion of owners who would consider further secondary factors.*

Of the remaining 37 per cent who would investigate further, it is possible that they will use 'home grown' evaluation techniques (Holt et al., 1993C). In some cases clients investigate these 'more specific' secondary evaluation criteria with (initial) prequalification. Where this happens, and there is a delay between prequalification and final selection (commonplace in public sector -refer Chapter 3) then any decline in a contractors corporate stability / performance occurring during this time will not necessarily be detected.

4.2.7. Discussion of the criteria -levels of overall importance

In the following discussion, decimals in brackets ie., {0.85} indicate final weighting indices W. Occasional reference to Table 4.12 might be useful.

4.2.7.1. Factor: Contractor organisation

Health & Safety policy with a weighted index of {0.58} emerged as being most important of all organisational variables. United Kingdom public sector authorities prequalification questionnaires confirm this finding.

Litigation tendency {0.54} ran a close second. Unsettled claims most often have to be determined via legal action, so this prominence is logical in view of the cost and time implications of protracted dispute resolution. A contractor with a strong litigation history is possibly experienced at claims and might even be classed as having an eye for opportunities to exploit. Furthermore, a firm submitting an extremely low bid may be reliant upon recouping potential losses via claims for extras. In view of this, association between lowest bidder and (lowest bidder) litigation tendency should be explored when evaluating tenders.

Quality control policy {0.52} ranks third seemingly reflecting client desire to attain a product of suitable standard. It is also cited by many writers on the subject of contractor selection as important (Baker & Orsaah, 1985; Russell et.al.1992).

Contractors could be measured by consideration of British Standard 5750 or the International equivalent[5] (Griffith, 1990). A relationship between this variable and *actual quality achieved* {0.66} (see the factor *past performance*) is established from the results. Resource availability -the most prominent function of a firm's *Size* {0.50} may be determined from analysis of current workload (possible overtrading) and trading capacity in relation to capital employed / net assets.

Age {0.43} of a company ranked fifth. The track record that 'aging' generates can instil greater confidence in a companys' longer term stability but this is not infallible, many long established companies have failed during the recent difficult economic climate. Nonetheless, it is a factor worthy of consideration in the prequalification process, but needs to be considered in terms of ascertaining whether a company has been suitably tested in its market place, by trading for a minimum number of years (explained in greater detail -Chapter 6 later).

Corporate image {0.40} achieved lowest rank amongst this subset of variables. Initially, one might question the relationship between image and performance, but it is suggested that image be considered in the preselection procedure, because 'prestigious' project owners will have an obvious wish to employ contractors of an equivalent standing in the market place.

4.2.7.2. Factor: Financial considerations

This is arguably the most important factor of all those considered. The financial stability of a contractor determines whether the company will stand or fall and therefore, figures high on the lists of many authors including (Russell, various; Diekmann, 1979; N.J.C.C. various).

Bank reference {0.66} and *Turnover history* {0.66} were the joint highest ranking

[5] Standard 9000: Quality Systems. International Standards Organisation, Switzerland.

variables under this factor. The latter is not surprising in that turnover is a measure of long term capacity (Janssens, 1991) along with providing an instant view of company trend ie., expansion or contraction. This aids the analysis of company activity, as well as being a constituent of several performance and stability ratios (Holmes & Sugden, 1990; Pilcher, 1992). The cost of obtaining this information is negligible -companies are required by the standard formats of The Companies Act (1985) to disclose turnover (total sales) in their profit & loss account.

Credit references {0.63} offer yet further insight into a company's financial standing, in particular, whether the firm is capable of paying creditors on time and should be considered at this stage of appraisal.

Surprisingly, amongst this set of criteria *ratio analysis of accounts* {0.63} achieved the lowest rank. This is astonishing in view of the vast amount of information that can be discovered from such an exercise, as was proven by the work of Abidali (1990).

In particular, Abidali used the current ratio*, net assets / current liabilities ratio* and interest cover* to predict the failure of construction companies (*see chapter 6 for explanation of their application to accounting figures). The value of this technique was demonstrated by Abidali's successful prediction of the demise of Rush & Tomkins Plc some three years before it happened.

4.2.7.3. Factor: Management resource

It is said that good managers can turn straw to gold whilst bad managers can do the converse -good managerial skills are a scarce commodity (Robbins, 1988). Hence, the importance of evaluating a contractor to discover his share of this precious human resource. It is generally accepted that good managers are trained, not born and this has been reinforced by the importance that respondents expressed in contractors operating a *formal training regime* {0.81}.

The *number of years* senior management have been *with a company* {0.69} came second, which could be construed as the relationship between the interest a company bestows in its managers and the reciprocal commitment of those managers to the company. However, one might argue that long serving staff are not sufficiently attractive to be head hunted! This criterion was closely followed by *qualification of the firms owners* {0.67}. Scope may exist here for investigation of a firm in light of the Chartered Institute of Building Chartered Company Membership Scheme (C.I.O.B. 1992). This requires company managers / owners to have minimum levels of chartered status. One respondent suitably summed this up: "involvement and capability of the company owners in the construction process, is crucial".

The *qualification of key persons* {0.64} achieved lowest rank. One client rightly pointed out, that an encouraging result from evaluating a company's management resource (ie., a contractor has an adequate number of qualified managers) does not automatically mean that those particular key persons will be employed on the forthcoming project. Therefore, it is necessary to consider *key persons available for the project* under secondary (tenderer) evaluation. That is, what portion of these qualified persons will actually be available for the project? Albeit a slight digression to this theme, perhaps there is future scope for incorporating into the employer / contractor contract a 'minimum qualification of management to be employed on the works' clause, thereby ensuring the client is afforded at least minimum management standards?

4.2.7.4. Factor: Past experience

This is another factor highly ranked by all practitioners. The *size of past projects completed* by the contractor emerged as the most important variable within this set and incidentally with the second largest weighting index amongst all criteria considered: {0.85}. The PR element of this score was 0.83, which would suggest that many owners have experienced problems with contractors who had taken on a project that was too large for them to handle (cf. Schleifer, 1990 earlier). Ensuring that the proposed project does not represent more than the maximum workload capacity for the given contractor seems the logical answer and may be determined from comparing trading capacity with current workload. At present this is most often attempted by applying a ceiling eg., do not award a contract if it's value represents more than (say) 20 per cent of the contractors' previous years turnover.

Local or national experience {0.74} ranked second and would be of particular interest to those clients seeking a continuity contract or serial tender where the works may be spread over a large geographic area. Investigation of this variable will also identify the firms' mobility potential which would be important where a fast response is necessary, such as for emergency work. *Type of projects completed* {0.73} ranked third. Obviously contractors with particular experience, especially on projects with a specific work type bias, should be a better prospect on future similar projects. This logic is borne out in that specialist contractors have evolved to deal with particular types of (specialist) work, such as M & E, lift installation etc.

4.2.7.5. Factor: Past performance

Investigation of contractor past experience tells the practitioner *what* projects a contractor has been involved with. How well such projects were executed will only be identified from an investigation of *performance*. This separation of experience and performance was earlier substantiated by Birrell (1988).

Failure to have completed a contract {0.67} ranked highest, being an understandable concern and in general agreement with findings of work in a similar vein conducted in the U.S.A. (Russell & Skibniewski, 1988). It seems that contractor inability to carry out obligations of a legally binding document, causes great concern. *Actual quality achieved* {0.66} ranks second and has been discussed above.

Number of contract overruns *cost* {0.57} and *time* {0.54} rank third and fourth respectively. Obviously, when assessing a contractor in light of these two variables it will be necessary to determine what percentage of such overruns are attributable to the firm's failing(s). Cost overruns are often entirely as a result of the client eg., variations. Furthermore, extraneous circumstances such as trade union boycotts cause time and cost overruns that are totally beyond the control of the contractor.

4.2.7.6. Factor: Project specific variables

Certain variables may appear to be re-considered under this factor. This is not the case. The prequalification factors are more broad in their analysis ie., applicable to any firm desirous to tender. This, and the following factor are project specific ie., applicable to tenderers. As an example, the prequalification variable *Qualification of key persons* was intended to generally evaluate company management resource. Under specific evaluation, the variable *Key persons available* shall determine the adequacy of key personnel that the contractor intends to make *available for the particular project*.

Qualification of key persons available for the project {0.67} emerged as the most important criterion under this factor correlating with the findings under *Management Resource* earlier. *Experience of similar construction* {0.56} and *key persons available for the project* {0.54} ranked second and third respectively. These appear to be variables that instil confidence, the former furnishing the client with an 'experienced' contractor in the sense that any potential problems should have been mastered during the execution of previous similar contracts, the latter already having been discussed. *Plant resource available* {0.48} ranked fourth, however, one would suspect that this would be of greater importance had the survey concentrated purely on civil engineering projects -due to their greater demand of this resource.

Geographic experience {0.40} was commented upon by many respondents in the context that a contractor needs to know the strengths, weaknesses and availability of local labour (refer also Janssens, 1992 earlier).

4.2.7.7. Factor: Other specific variables

Current workload {0.86} (to be assessed at the time of evaluating the tender) ranks highest and also achieved the top overall ranking amongst all variables considered in the analysis. One can sensibly assume that client's fear of a contractor being unable to complete a contract due to overtrading is the fundamental reasoning behind the response. Current workload needs to be assessed during the tender evaluation period to identify any *recent* increase in workload (ie., since prequalification).

Time of year -weather {0.76} came second. Perhaps this is a reflection of the way the British climate is often able to hamper construction work. Such an adverse effect on programme can result in client dissatisfaction in terms of 'time'. However, it will be difficult to discriminate between contractors because potential exposure is usually common to all tenderers. Perhaps an 'index' may be possible which reflects probable 'downtime' from bad weather -in relation to geographical location / time of year / contract duration. Although not discriminatory this may help predict one aspect of potential project success. *Prior relationship* {0.65} between owner and contractor ranked third and has obvious ramifications.

Home office location in relation to the project {0.64} came fourth. This is relative to communication and speed of decision making between contractor Head Office and site management. In a similar vein, one particular respondent highlighted the importance of "the autonomy of site offices". *Form of contract* {0.59} came bottom of the list. Liaison with clients, has revealed that the majority do not consider the latter important because *they* decide what form of contract is to be used (normally JCT). Where this is not necessarily the case eg., contractors own contract conditions, then the owner must assess the apportionment of risk.

4.3. CONTRAST: LITERATURE SEARCH AND THE SURVEY

4.3.1. Comparison

The literature review initially identified some forty nine potential selection criteria which were grouped under five generic subject heads (Tables 4.3. to 4.7.).

Based upon their frequency within the literature observed, these variables were initially ranked relative to each other. These initial rankings, are shown alongside the overall ranks subsequently assigned to the thirty one criteria as determined from the national survey, in Table 4.16. Although of interest in the context of a comparison measure, the initial rankings are to be viewed with reservation for the reasons highlighted earlier (section 4.1.1.).

4.4. SUMMARY

A literature review identified the selection criteria considered by authors and commentators as essential in contractor selection. Most preeminent were *financial analysis* of the contractor and *experience* in terms of size and type of projects.

These early indicators influenced a structured questionnaire survey which was carried out amongst industry selection practitioners and clients. The subsequent data were analysed to establish overall relative importance rankings for the criteria. Such quantification facilitates their incorporation into the proposed selection model.

From the survey findings *resource availability* (current workload) and *experience* related criteria were amongst the highest ranked, which correlates with the indications of the literature review.

In common with the areas of weakness highlighted in Chapter 2, the survey also confirmed the particular prominence attached to prequalification by practitioners, along with a lack of secondary investigation to assist with the evaluation of tenderers and hence final selection choice.

Considering the final ranking of criteria the six highest scoring are;

1. *current workload*
2. past experience in terms of *size of projects completed*
3. management resource in terms of -*formal training regime*
4. time of year -*weather*
5. past experience in terms of catchment ie., *national or local*
6. past experience in terms of -*type of projects completed.*

Obviously, it would be difficult to discriminate between contractors in terms of weather because exposure will be equal to all firms.

It would seem prudent therefore to include the remaining five selection criteria in any selection method.

Table 4.16.
Comparison of Ranks -literature search / survey

	From Literature Search		From National Survey	
n	*Criterion*	*Rank*	*Criterion*	*Rank*
1.	Non specific financial analysis	1	Current workload	1
2.	Experience size of projects	3	Experience size of projects	2
3.	Experience non-specific	3	Formal training regime	3
4.	Experience type of projects	3	Time of year - weather	4
5.	Current workload	6	National/local experience	5
6.	Structure of organisation	6	Experience type of projects	6
7.	Qualification of key persons	6	Management - years with company	7
8.	Resources non-specific	8.5	Failure to have completed contract	8
9.	Turnover history	8.5	Qualification of company owners	9
10.	Management structure	12	Qualification (key persons for project)	10
11.	Ownership of company	12	Bank reference	11
12.	Technical competence	12	Turnover history	12.5
13.	Performance non-specific	12	Past quality achieved	12.5
14.	References - past clients	12	Prior relationship	14
15.	Insurance cover	19	Qualification key persons (within Co')	15
16.	General reputation	19	Home office location	16
17.	Plant acquisition policy	19	Credit reference	17
18.	Number employees/trends	19	Ratio analysis accounts	18
19.	Quality control record	19	Form of contract	19
20.	Claims consciousness	19	Health and safety policy	20
21.	Location of office to project	19	Overruns - cost	21
22.	Share portfolio	19	Experience of similar construction	22
23.	Anticipated cashflow	19	Key persons available for project	23
24.	Subcontractor policy	27.5	Litigation tendency	24
25.	Assoc Co'/joint venture details	27.5	Overruns time	25
26.	Co membership trade organisations	27.5	Quality control policy	26
27.	Health & safety policy	27.5	Size of company	27
28.	Time overruns	27.5	Plant resource available	28
29.	Experience key personnel	27.5	Age of company	29
30.	Analysis - financial statements	27.5	Geographic experience	30
31.	Understanding of project	27.5	Company image	31
32.	Geographic experience	35.5	FIN	
33.	Contractors design experience	35.5		
34.	Bank references	35.5		
35.	References - non-specific	35.5		
36.	General attitude	35.5		
37.	3rd party recommendation	35.5		
38.	Fabrication facilities	35.5		
39.	Area of catchment	35.5		
40.	Parent company details	44.5		
41.	Risk attitude	44.5		
42.	Nationality	44.5		
43.	Training regime	44.5		
44.	Key persons corporate membership	44.5		
45.	Equal opportunities policy	44.5		
46.	Labour relations	44.5		
47.	Willingness to resolve problems	44.5		
48.	Prior relationship	44.5		
49.	Non completion of contract	44.5		

CHAPTER 5

DEVELOPMENT OF AN ALTERNATIVE CONTRACTOR SELECTION MODEL

5.0. INTRODUCTION

This chapter underlines the intrinsic link between decision making and the fundamental objective of this research, that being to select the optimum choice (best contractor) from amongst a set of alternatives (all contractors desirous to tender). This is then followed by an overview of modelling solutions in the specific context of solving such decision 'problems'. Because *this* decision problem cannot be immediately characterised in terms of a single value and, because there is the need to consider several disparate outcome dimensions, the multi-attribute analysis (MAA) technique is identified as the operational research (OR) tool to be employed. A 'stepwise logic' necessary to conduct the selection decision task is then devised, around which the MAA model is subsequently moulded. This developed model is fully elucidated and mathematically presented. As a conclusion to the chapter, a detailed flow chart consolidates the components of: i) the stepwise process ii) the elements of the model and iii) the relationship of mathematical inputs / outputs.

5.1. DECISION MAKING

Development of a contractor selection model, was essentially a mission to create a decision tool. This is evidenced by the fundamental ambition to select *one* contractor from amongst all those available: "A decision problem is characterised by the availability of more than one course of action" (Kaufman and Thomas, 1977). That is, there must be a choice between alternatives for there to be any decision at all (Skitmore, 1989). North (1968) contended that "Decision theory may be regarded as a formalisation of common sense, however, mathematics provides an unambiguous language in which a decision problem may be represented".

Notwithstanding the age of this quote it neatly encapsulates the theme of this Chapter.

From the inception of a project a client must make numerous decisions, the majority of which will influence the venture in terms of success or failure. The task of identifying appropriate bidders *and ultimately selecting the 'best' contractor*[1] is one such decision (Russell et al. 1992). "During the planning phase of a construction project an owner needs to decide what level of contractor evaluation to expend and what method to use" (Jaleskis & Russell, 1992). This could equally be described as "what method of decision theory to apply". At the risk of complicating even *this* foremost decision, one must consider that contractor selection alone is not a definitive indicator of project success (ibid), hence, deciding what method of decision theory to apply to a given decision problem is a decision in itself!

The core of *this* decision problem is rational evaluation. Evaluation of the available set being made difficult by the interaction of the objectives[2] of the client and the attributes[3] of the contractors (Diekmann, 1979). The problem is complicated by disparity at the input stages ie., contractor characteristics and owner perceptions of acceptable standards / expectations.

The necessity of making decisions, particularly in the face of uncertainty or limited information is an integral part of everyday life. We very often have to act without fully knowing the consequences that will result from the action (North, 1968). Many decisions are particularly difficult to make because their outcome is uncertain, being subject to large amounts of variation (Kidd, 1985). However, decision theory

[1] Italics by writer.

[2] A criterion is a measure of effectiveness, it is the basis for evaluation. Criteria may emerge in the form of attributes or objectives in the actual problem setting. In this context *objectives* are measures by which options may be evaluated and, are to be pursued to their fullest.

[3] *Attributes* are performance parameters: 'components', 'factors', 'characteristics' and 'properties' are synonyms for attributes. An attribute(s) should provide a means of evaluating an objective. A selection alternative may be characterised by a number of attributes -being a function of the decision maker's objectives.

provides a rational framework for choosing between alternative courses of action when the consequences resulting from this choice are imperfectly known.

An owner attempting to confidently assign a construction contract has to perform a similar role to the aforementioned uncertain everyday decisions: endeavouring to choose a contractor who will deliver a service to desirable standard, on time and to budget, whilst more often than not having to deal with many elements of the 'unknown'. In addition, some owners face further impediment as there is substantial variance regarding the quantity / quality of information and awareness / experience of the construction process that they possess, and are therefore able to draw on throughout (Rowlinson, 1988).

Decision making is one of the most common forms of mental activity known to man, nonetheless, there does not appear to be any complete theoretical basis that adequately describes or models the actions involved (Skitmore, 1989). However, Kaufman & Thomas (1977) suggested that it is essentially a three stage process in which the decision maker (DM) must;

a) identify the decision alternatives (available options / courses of action);
b) estimate the consequences of each (evaluation / predicted outcomes);
c) make the decision: normally select optimum alternative as a result of (b).

Skitmore also confirmed that the relationship between alternatives is very often complex and interrelated (refer Diekmann above) thereby requiring thorough identification of available options and, comprehensive evaluation of the same before a final, *rational* choice can be made.

An alternative approach to that described in (a) to (b) would be for the DM to contemplate, or more specifically 'design' a perfect choice for the given problem, then search until it is found (see MOA below). However, in this setting design /

search would be unrealistic because the cost of accruing the necessary information and searching out the optimum solution, would be unacceptably high. Any evaluation procedure should not make informational demands in excess of that data commonly available, since excessive data requirements only serve to make the procedure inordinately expensive and therefore not practical (Diekmann, 1979).

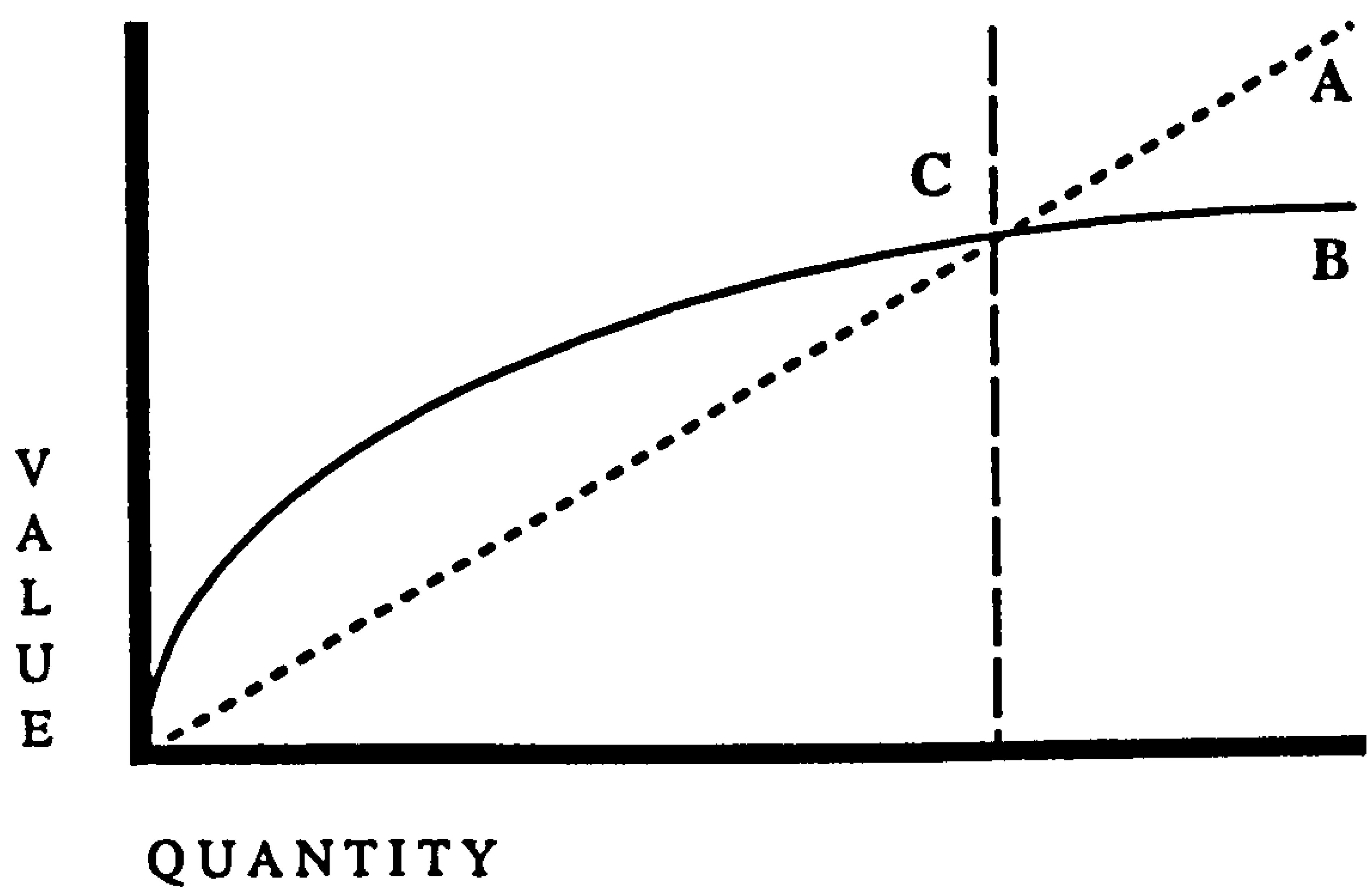
This latter point is important: information must be reasonably accessible. This is because the relative value of accumulating information is non-linear, a greater proportion of 'value' accrues from earlier increments of expenditure (Moore & Thomas, 1979). Figure 5.1. demonstrates this cost / value relationship. Intersect C on the Figure is particularly relevant -it may be described as a point of equilibrium. That is, the point beyond which it becomes non-profitable to seek further information because the cost outweighs any extra expected gain from the optimum decision.

The need for decision aids arises out of the conjunction of two factors; limited human rationality and the information processing demands of complex problem situations. Mascoll (1984) contended that given perfect rationality, then the solution to any problem is strictly determinate. But, this may be questionable in the case of stochastic or indeterminate scenarios. Furthermore, a number of decision theorists have challenged the classical model of rational choice because of it's heroic assumptions *about* human rationality ie., 'normal' human choice behaviour exhibits limited rationality, stemming predominantly from physiological restrictions such as perception, computation, organisation and utilisation of memory.

This recognition of limited human rationality in a complex decision making scenario, has resulted in growing interest as to how decisions are, and should, be made. Specifically, evidence indicates that accumulated experience is a major component of high level decision making skill (ibid).

Figure 5.1.

The relationship between cost and value of information



Gradient 'A' represents the cost of obtaining information, shown here to be linear, but this may not always be the case. Curve 'B' corresponds to the value of information in terms of the extra expected gain achieved from the optimum decision relative to the information input. It can be seen that expected gain is zero at intersect 'C' and becomes negative thereafter.

Adapted from Moore & Thomas, (1979).

For instance, with reference to the *compilation* of tenders it has been found that "successful bidding is more of an art than a science needing years of hands-on experience" (Ahmad & Minkarah, 1988). Current contractor selection methods also exhibit a strong reliance upon this phenomenon of accrued experience ie., selection skill (cf. Russell & Skibniewski, 1988). In a real life selection setting this experience is often relied upon in combination with the practitioners' fostered intuition.

With regard the *complexity* of decision problems, solutions (ie., techniques) have evolved commensurate with varying levels of problem intricacy. Subsequently, the decision technology employed will be dependent upon the specific requirements of the problem encountered. Techniques available and typical applications include; linear programming (predominantly resource planning), decision-tree analysis (decision tasks with a smaller number of options and limited number of outcomes at each stage of the process), multi-attribute analysis (settings with a greater number of options and possible outcomes), probability theory (analysis where numeric probabilities of events and outcomes are computed), utility theory (accounting for practitioner / DM subjective preferences) and sensitivity analysis (where effect of changes in decision parameters may be observed on outputs). See Kaufman & Thomas (1977), Moore & Thomas (1979), Holloway (1979), Croucher (1980), Rivett (1980), Turban (1988) and Russell (1992).

5.2. MODELS -AN OVERVIEW

It is not the intention of this portion of text to cover with intensive detail the complex area of modelling and operations research (OR). A copious amount of literature abounds for a thorough investigation of the subject where required. Rather, a succinct overview is offered which aims to furnish an appreciation of the interrelationship between the initial problem, modelling tools and a solution. A perfect analogy to this intention is offered by Kidd (1985) who stated that; "The newcomer to do-it-yourself will benefit more from learning how and where to use an electric drill, than from studying the theory or construction of the motor which drives it".

5.2.1. Some definitions

Firstly it is helpful to put OR and modelling into context; "Operational research is the attack of modern science on complex problems arising in the management of resources. The distinctive approach is to develop a scientific model of the system incorporating measurements of factors such as chance and risk, with which to predict and compare outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically" (Pilcher, 1992).

In short, OR attempts to find an optimal solution to a given problem. *Models* and *algorithms* are tools for analysing or processing such problems, the contractor selection task being typical. Defining some of the more common modelling terms, contributes to an appreciation of the subject, thereby helping to decide what 'tool' is optimum for a given scenario;

The personal beliefs, values and philosophy of each individual are what help guide each of us through life in the context of making our 'everyday' decisions. These are *implicit models* ie., implied though not plainly expressed (Oxford, 1992). We may perceive implicit models as being part of the individual and therefore generally inaccessible to others. To have value beyond the bounds of the individual, implicit models need to be transposed into *explicit models* ie., expressly stated (ibid). Being open to scrutiny the latter are therefore also prone to change or challenge, application to the problem and, ultimately validation (cf. Holt, 1994).

Explicit models may be further sub-classified as either *physical explicit models*, such as a scale model mock up for physical testing purposes: wind, load etc. or *symbolic explicit models* which include the most familiar OR techniques of (or a series of) mathematical equations.

It is the latter category with which this research need be concerned. Included within the symbolic explicit model are generally three parameters;

a) *variables* -by virtue of their designation these are components most prone to variance and are therefore often represented by a symbol (a, b, x, y, μ, f etc.);

b) *constants* -which by virtue of their (constant) nature are more often able to be represented by a numeral (a symbol will be employed if unknown);
c) *coefficients* -these are multipliers of multiplicands normally variables. Values of coefficients may or may not be known.

Models may also include *inequalities*. These are relationships such as 'less than' 'as well as' or 'instead of'. The incorporation of inequalities often help the practitioner to better mirror reality. A term often used in this context is that of a *constraint* eg., reject a contractor if financial score / measure is below *x*.

Variables themselves are worthy of more detailed attention. Policy or strategy (see types of model below) may be expressed within the model by values of *decision variables* -which are some or all of the *controlled variables* (the latter being controlled in terms of 'value' by the practitioner). Variables which give information about the effects of a policy are *state variables,* whilst a variable used to judge an outcome is called a *criterion* or *objective function*. *Uncontrolled variables* are beyond the control of the practitioner, but are generally regarded to have (or models must be designed so that they have) minimum impact and be common in magnitude to all options being tested or investigated by the model.

5.2.2. Types of model

Testing the effect of a policy or strategy is achieved by employing a *descriptive* or *what if* model. Descriptive models do not however, necessarily point toward or identify the best option or result. Where such identification is required then this must be achieved via a *prescriptive model* which itself may take the form of either;

a) *An algorithm* -designed to identify the best strategy in accordance with the selection / discriminating criteria assigned it.
b) *An heuristic* -designed to perform in a similar way but that the strategy identified is not guaranteed to be the best one.

Caveat: this last statement (b) implies that an algorithm *will* select the best policy *but this will only be as good as the selection criteria assigned to the model and, the integrity of the model itself.* Therefore, the best protection against a bad outcome is a good procedure! (North, 1968).

Kidd (1985), contended that whichever approach is adopted there is no 'right answer' as to how much detail should be included in a model and further went on to state that in simple terms if it helps to make a better decision, then it is a good enough model. This statement is prone to debate, after all -what is a better decision?

Indeed, contrast is evident if Mascoll (1984) is observed; "There is an important distinction between good decisions and good outcomes..that is the difference between the effectiveness of the procedures used to choose actions and the extent to which appropriate courses of action are chosen". He continued; "A good decision making procedure systematically utilises all the available information to arrive at a decision which is coherent. Such a procedure should minimise the likelihood of an unfavourable outcome but cannot guarantee a good result".

With further specific reference to decision models, we may classify them as either *option orientated* or *output orientated*;

> Option orientated models are associated with always choosing the same option. For example, always backing the favourite horse in a race or, always selecting the largest number. This is why option orientated models are said to have an inherent *'policy'* eg., the policy to identify shortest odds or the policy to highlight greatest numerical result in the examples given.
>
> Outcome orientated models attempt to relate each decision option being considered with the anticipated outcome of that option ie., should that outcome ultimately be selected. Such models therefore possess an inherent

strategy, that is, the strategy governs the decision by dictating choice amongst anticipated outcomes. Normally, outcome (strategy) models cost more to implement because they utilise a greater amount and, better quality of information (refer cost of information earlier). However, the cost should be justified in so far as strategy models offer a greater probability of the outcome selected, being the most suitable / favourable as determined by the decision parameters within it (Skitmore, 1989).

5.3. REQUISITE CHARACTERISTICS OF A CONTRACTOR SELECTION MODEL

In view of the principal characteristics outlined thus far, we may begin to typify the required contractor selection model as being an outcome orientated, symbolically explicit algorithm. It should have an inherent strategy (to choose the best contractor) and be prescriptive (by highlighting such).

Kidd (1985) indicated a suitable decision analysis technique in the form of a stochastic algorithm. To be applicable the following assumptions need, and in this case do, apply;

a) that the possible options are known (contractors desirous of contract award);
b) that the decision maker can be identified (practitioner / client);
c) that the possible outcomes are known or can be determined (performance potential for each contractor).

The most suitable technique therefore, is one of multi-criteria decision making (MCDM). The method refers specifically to the making of decisions in the face of uncoupled, multiple (decision) criteria (Moselhi & Martinnelli, 1990). Initially, one may classify MCDM in terms of multiple-objective analysis (MOA) and multi-attribute analysis (MAA) (Hwang & Yoon, 1981).

MOA is a problem solving technique where the objectives (decision alternatives) are not predetermined and is therefore commonly used for design. That is, design the best option according to owner objectives. Such an approach is unsuitable for contractor selection (refer cost of information / implementation earlier, also refer section 3.2.4.b). Furthermore, MOA is infeasible as one could not guarantee *finding* a perfect solution.

Conversely, MAA is capable of helping to select (identify) optimum choice in respect of the same objectives but where the decision options are predetermined. Hence, MAA is suitable for the multi criteria / multi alternative nature of *this* selection problem.

Mascoll (1984) also pointed out specific features of the multi attribute analysis technique which render it optimal to this type of application; "MAA is a quantitative approach which facilitates the consideration of multiple attributes. Options being evaluated may be rated against the clients' objectives (criteria). Preferences may be incorporated by assigning importance weights. Ratings and / or weights may then be combined to yield a score -the highest score indicating optimal choice". He went on to underline further desirable features of the technique; "Firstly it addresses the multi attribute nature of real world decision making, secondly it encompasses decision maker judgments, thirdly the decision inputs are assessed in a systematic fashion to produce overall evaluations. Finally, the procedure is reliable in the sense that results are reproducible".

However, the method is not without it's handicaps. The disadvantages of MAA are widely diverse but generally share the following characteristics;

d) *Multiple objectives / attributes* -each decision problem will have it's own multiple objectives / attributes for the given setting. These must be identified.

For this study owner objectives have been confirmed in the form of selection criteria as determined from the literature search and survey, elucidated in Chapter 4. Attributes of each contractor must be measured in respect of these objectives as a means of overall evaluation.

e) *Conflict amongst criteria* -multiple criteria very often conflict with each other. For example, the objective of a contractor having adequate *spare workload capacity* for a proposed project, may conflict with the objective *financial stability*. This is because spare workload is a function of a contractor not working to capacity, whilst financial stability is in part a function of a full order book!

An objective being evaluated must therefore trade off against the others (gain in one attribute being set off against reduction in another) but, all measures must relate to realistic targets as determined by owner predilection[4] or proven limits[5]. For the example described, then adequate capacity means; in relation to company assets and liabilities, whilst financial stability means; maintaining a healthy return on capital employed.

f) *Incommensurable units* -most objectives / attributes have different natural units of measurement. For instance, *failure to have completed a contract* is binary (yes / no), whilst *experience of similar construction* may be numeric; (number of projects) or descriptive; (limited experience, adequate, excellent etc).

For inclusion in the model such incommensurable, often ordinal data have to be converted to a common scale of measurement (eg., 0.0. to 1.0.). This may be

[4] Owner predilection may be incorporated into MAA by the inclusion of utility functions or utility curves as they are termed.

[5] These are tangible measures such as accounting ratios for financial stability or bid level in relation to owner estimate / mean tender level.

achieved via utility theory (see Hwang & Yoon, 1981; Martinnelli, 1986; Moore & Thomas, 1976; Moselhi & Martinnelli, 1990). However, the model will exploit a series of independent attribute evaluations for such conversion to interval data (Chapter 6).

g) *Design / selection* -as intimated, solutions to these problems are either design the best option, or select the best one from amongst previously specified finite alternatives.

It is the latter alternative with which this study is concerned; the former having been dismissed for the reasons of impracticality and cost explained earlier.

Any multi-attribute problem may be concisely expressed in a matrix format (Hwang & Yoon, 1981). As an example and in the context of contractor selection, then let us assume that;

a) decision alternatives are contractors: 1,2,....m (Cr_j);
b) client objectives are attributes: 1,2,.....n (X_i).

Then, if all attributes are measured and plotted in respect to each alternative, x_{ij} become the objective functions within such a matrix, indicating the respective results of evaluation. That is, the value of attribute i, X_i with respect to alternative j, Cr_j.

Hence, Cr_j, (j = 1, 2,.....m) may be denoted (and analysed) by the row vector; $\{x_{1j}, x_{2j},....x_{nj}\}$.

The column vector; $[x_{i1}, x_{i2},......xi_m]$ shows the value of each alternative in regard to the *ith* attribute, X_i.

This matrix approach is shown in Table 5.1.

Table 5.1.
MAA matrix -objective functions, row and column vectors

		Client objectives Attributes X_i (1 to *n*)			
		X_1	X_2	X_3	X_n
Decision alternatives	Cr_1	$[x_{i1}]/\{x_{1j}\}$	$\{x_{2j}\}$		$\{x_{nj}\}$
Contractors Cr_j	Cr_2	$[x_{i2}]$ ...:	......:	......:	
(1 to *m*)	Cr_3	:......	: ......:	......:	
	Cr_4	: ......:	......:	......:	
	Cr_5	: ......:	......:	......:	
	Cr_m	$[x_{im}]$ ... :	......:	......	x_{nm}

KEY
{ } = row vector
[ ] = column vector

Co-ordinates Cr_1:X_1 identify the objective function as an element of both the column and row vectors respectively. In any event, an objective function may be expressed as x_{ij}.

5.3.1. Optimal / best MAA solutions

This area has been reported by Hwang & Yoon (1981); "An optimal solution to any MAA problem is one which results in the *maximum* value of each of the objective functions (x_{ij} above) simultaneously.

For example, having evaluated each alternative Cr_j to attain values for each of the attributes X_i, the optimal solution ie., decision alternative (Cr_j*) would be that which resulted in the maximum possible value for each of it's objective functions within the matrix (x_{ij}*) simultaneously. That is, x_{ij}* is an element of attribute X_i in respect of alternative Cr_j* and all functions of x_{ij}* $\geq$ all functions of x_{ij} for remaining alternatives Cr_j. Hence, Cr_j* is the optimal solution if x_{ij}* ε X_i and $fx_{ij}^* \geq fx_{ij}$ for all remaining $x \, \varepsilon \, X_i$.

Unfortunately, such a solution is only achievable by chance. The matter is further complicated by the conflict described earlier (5.3.e) that is, usually there is no *optimal* MAA solution possible since it is the core of the problem to have conflict between objectives, requiring the trade-off discussed.

Hence, x_{ij}* is seldom achievable for <u>all</u> x ε Cr_j*. Therefore, the ideal solution (SCr_j*) will consist of objective functions (s_{ij}*) where; $s_{ij}^* = (f1^*, f2^*, \ldots. fj^*)$, when fj^* is an optimal *but feasible* value. Nonetheless, even this may be hard to achieve due to the conflict mentioned. This results in the best solution being a subjective one in that it is composed of the most preferable values within the matrix ie;

$$SCr_j^* = \sum_{i=1}^{n} s_{ij}^* \qquad \text{(Eq 5.1)}$$

in which SCr_j* is the ideal solution; n = number of attributes measured; s_{ij}* = ideal objective functions consisting of: $(f1^*, f2^*, \ldots\ldots fn^*)$ when $fn^* = \max U_j(f_{ij})$ (i = 1,2,.......m), and U_j indicates the value / utility function of the jth attribute.

In short, the ideal solution (optimal selection choice) is that which exhibits the most preferable, but feasible results of attribute evaluation without containing any values (objective functions) that fall below predetermined, or critical limits as set by the practitioner nor, any values that if 'bettered' would (via trade-off) impede or weaken the results of another objective function, below which that weakened function would fail to remain feasible.

Having looked at the theory of MAA and introduced the matrix approach, we may now develop the technique towards the required specific application.

5.3.2. Tuning the MAA concept to the problem of contractor selection

Two particular forms of MAA permit application of the technique to a wide range of decision problems (Moore & Thomas, 1976); namely *linear* and additive *models*. Linear models imply that attributes are capable of being readily quantified on a commensurable scale and are formalised by;

$$ACr_j = \sum_{i=1}^{n} V_{ij} W_i \qquad \text{(Eq 5.2.)}$$

in which ACr_j is the aggregate score for contractor *j*; V_{ij} is the variable (attribute) score achieved by contractor *j* in respect of criteria (objective) *i*; W_i is the importance or utility weight of attribute *i* and, *n* is the total number of selection criteria included in the model (ibid; Russell, 1992).

Linearity assumes a constant rate of trade-off between conflicting attributes. For instance, if a client were considering *inter-alia* current workload (percentage workload of maximum capability) and workload capacity (£K) then the statement "every 10 percent increment of vacant workload will be considered as worth £100K in terms of workload capacity" would apply.

Alternatively, additive models formally state that;

$$ACr_j = \sum_{i=1}^{n} V_{ij}(x_i) \qquad \text{(Eq 5.3.)}$$

where the components are as per equation 5.2. and V_{ij} is the variable (attribute) score achieved by contractor *j* in respect of criteria *i*; but being a function of the elements (x_i).

To revert to the client scenario given under equation 5.2. then assuming additivity, statements to the effect; "10 percent of vacant workload will be considered as worth £100K of workload capacity, whilst 20 percent vacant workload will be considered as worth £250K" would apply ie., there is non-linearity between conflicting attributes. The additive model may also incorporate weights / ratings, resulting in an equation of the form;

$$ACr_j = \sum_{i=1}^{n} W_i \, V_{ij}(x_i) \qquad \text{(Eq 5.4.)}$$

This equation may be further formalised as;

$$ACr_j = \sum_{i=1}^{n} W_i \left[\sum_{m=1}^{p} V_{ij}(x_{ijm})\right] \qquad (5.5.)$$

where the components are as per equation 5.4. and x_{ijm} is the *m*th objective function of V_i (m = 1,2,.....p) in respect to contractor *j* . *m* might be expressed in 'utiles' (see later).

Generally, with regard the weights and variable scores;

$$0.0 \leq \sum_{i=1}^{n} W_i \leq 1.0 \qquad \text{(Eq 5.6.)}$$

and;

$$0.0 \leq \sum_{i=1}^{n} V_{ij} \leq 1.0 \qquad \text{(Eq 5.7.)}$$

thereby, ensuring that $0 \leq ACr_j \leq 1.0$. However, where $\sum V_i$ and / or $\sum W_{ij} > 1.0$ then the following equation may be applied to achieve a unified aggregate score;

$$UACr_j = ACr_j/ACr\,Max \qquad \text{(Eq 5.8.)}$$

in which $UACr_j$ is the unified aggregate score for contractor *j*; ACr Max is the maximum attainable aggregate score and ACr_j is the aggregate score achieved by contractor *j* as determined under any of the equations 5.2. to 5.5. above.

5.3.2.1. More about objective functions

Ascertaining a numeric value for each contractor attribute xi_j, may adopt a quantitative or qualitative approach. The distinguishing feature of MAA is that attributes may not necessarily be quantifiable (Hwang & Yoon, 1981 also refer 3.2.4.). Therefore a combination of both quantitative and qualitative methods may be employed (Bohanec & Urh, 1991). The most simple qualitative means of evaluation would result in the type of subjective values offered in the worked example given later under section 5.4. These are known as simple scoring models (Janssens, 1991).

5.3.2.2. Importance weights

If objective functions x_{ij} are determined via utility curves these may be implied as decision maker abstract levels of importance. Such weights in themselves may be used for decision analysis via formulae similar to that given in equation 5.1. However, importance weights (refer equation 5.2.) make the MAA output more sensitive and reliable by accentuating options that score well in objective functions weighted high by the user and vice-versa.

Use of *approximate* weights or ranks can simplify the decision process because; i) detailed time consuming weight elicitation can be avoided ii) the decision maker may be unavailable or unwilling to specify precise weights iii) where no single decision maker is available a group may only be able to agree at a rank order level (Hutton Barron, 1991). Three approaches have been identified based on no information or only rank order information; i) arbitrary selection ii) exploitation of pairwise dominance iii) use of partial information as constraints in mathematical programming (ibid).

In short, detailed weight elicitation can be complex but is worthwhile for inclusion in MAA, because of the benefits mentioned (see Russell & Skibniewski, 1988; Holt et al., 1993C).

5.3.2.3. Utility

Utility functions qualify the preferences of a decision maker by assigning a numeric index to varying levels of satisfaction to an objective ie., a utility function is the transformation of some level of contractor performance into an abstract, numerical equivalent of satisfaction (Diekmann, 1981). If a utility value (normally expressed in utiles) is defined by U_i then U_i may be multi-dimensional being a function of several sub-objectives in itself. This leads to the derivation of U_i being similar to that shown in equation 5.3. ie., $U_i = U(x_i)$ where $x = 1,2,....m$, *m* being the number of dimensions considered in respect of U_i. In simple terms, the greater the utility value assigned to an attribute, the more important / greater impact / greater preference is exhibited by the decision maker for that attribute ie., if $U_i > U_a$ then U_i is preferred to U_a.

Such distinction between attributes is required to i) discriminate between options and ii) analyse the effect of changes to evaluation of a single option. Hence magnitude of utility is not as important as *relative proportion* (Bohanec & Urh, 1991). Therefore, a simple means of determining utility values is used within the new contractor selection model which gives transformation of qualitative, linguistic values into numeric, abstract equivalents onto an interval scale 0.0 to 1.0. Further graphical example of utility weight extrapolation is given in the examples that now follow.

5.4. EXAMPLE APPLICATIONS

That the MAA method is particularly suitable for construction decision problems is evidenced by the number of authors who have applied the technique to some extent and in one form or another. These include: Skitmore & Marsden (1988), Moselhi & Martinnelli (1990) Harris & McCaffer (1991) Janssens (1992) and Russell (1992). Some of these examples are included in the discussion that follows, to explore the methodologies, identify weaknesses in approach and hence develop the most suitable model for the problem under scrutiny.

As an initial example we may observe the principles of the 'matrix' approach discussed earlier. Assume six contractors Cr_1 to Cr_6 (Cr_j) are being subjected to prequalification. Then each firm may be evaluated in light of the generic prequalification factors identified from the survey in Chapter 4 earlier; *contractors organisation; financial stability; management resource; past experience* and *past performance*. If these generic factors are designated as X_1 to X_5 (X_i), then the results of contractor evaluation expressed in natural values may be as shown in Table 5.2. The problem discussed earlier of incommensurable units is now instantly recognisable.

However, transposition of these natural attribute units into commensurable values results in a matrix somewhat easier to evaluate -see Table 5.3. The most simple form of additive MAA may now be observed (refer equation 5.3.) ie., $\sum x_{ij}$ for each alternative Cr_j is shown in column 6 this total being ACr_j. Subsequent unified scores (refer equation 5.8.) exhibit the values given in column 7 ($UACr_j$). That is, because $\sum x_{ij} > 1.0$, then for *say* Cr_6: $ACr_j/ACr_jMax = 3.6/5.0 = U\,ACr_1 = 0.72$.

Finally, the rank order is now easy to establish and identifies contractor 1 as being the best alternative in this instance.

Table 5.2.
Decision matrix one -alternatives Cr_j in respect of attributes X_i given natural values

		Generic Discriminating Factors: Attributes (X_i)				
		X_1	X_2	X_3	X_4	X_5
		Contractors organisation	Financial stability	Management resource	Past experience	Past performance
Contractor	Cr_1	Acceptable	Yes	Acceptable	Excellent	Good
Alternatives	Cr_2	Good	Yes	Abundant	Limited	Good
(Cr_j)	Cr_3	Good	No	Limited	Limited	Bad
	Cr_4	Bad	Yes	Acceptable	Acceptable	Excellent
	Cr_5	Acceptable	No	Acceptable	Excellent	Bad
	Cr_6	Good	Yes	Limited	Limited	Good

Albeit simplistic in design, the example underlines the efficiency of this type of MAA, such being termed simple scoring models. Their main advantage is that they are easy to apply and hence, are frequently used in industry (Moselhi & Martinnelli, 1990).

However, simple scoring models have limitations because they rely heavily upon subjectivity in terms of;

Table 5.3.
Decision matrix two -alternatives Cr_j in respect of attributes X_i given commensurable values

		Generic discriminating factors: Attributes (X_i)							
		X_1	X_2	X_3	X_4	X_5	$\sum x_{ij}$	$UACr_j$	Rank
	Cr_1	0.5	1.0	0.5	1.0	0.8	= 3.8	0.76	1
	Cr_2	0.8	1.0	0.9	0.2	0.8	= 3.7	0.74	2
(Crj)	Cr_3	0.8	zero	0.2	0.2	0.1	= 1.3	0.26	6
	Cr_4	0.2	1.0	0.5	0.8	1.0	= 3.5	0.70	4
	Cr_5	0.5	zero	0.5	1.0	0.1	= 2.1	0.42	5
	Cr_6	0.8	1.0	0.2	0.8	0.8	= 3.6	0.72	3

a) number and nature of criteria (X_i) assigned;

b) determination of the value x_{ij} -this usually being an implicit function ie., $x_{ij} = x_{ij}(x'_{ijm})$ where $x'_{ijm} \in x_{ij}$; m = number of sub factors normally *subjectively* considered by the practitioner.

A further variant of simple scoring in this context is given below (Janssens, 1991). An improvement on simple scoring is achieved by introducing importance or utility weights (W_i), thereby accentuating ACr_j for those firms who score well under criteria perceived as important by the decision maker (client / practitioner) and vice-versa. Such an approach mirrors equation 5.4.

As an example, we may utilise the same attribute scores as given in Table 5.3. but introduce (arbitrary) importance weights ($0 \leq W_i \leq 1.0$) as follows; *contractors organisation* = 0.15; *financial stability* = 0.25; *management resource* = 0.2; *past experience* = 0.3; *past performance* = 0.1. Analysis is now as shown in Table 5.4.

Note: because; $\sum W_i = 1.0$ and; $0.0 \leq V_i \leq 1.0$ then; $0.0 \leq ACr_j \leq 1.0$, so equation 5.8. need not be applied to unify the final score.

It can be seen that Cr_1 maintains highest rank but the firm has increased it's margin over the nearest rival by 5 percentage points, reflecting good attribute scores in objectives perceived as important by the client (eg., $V_i = 1.0$ for financial stability when $W_i = 0.25$). Cr_2 having been ranked second by the simple scoring technique has now been relegated to fourth whilst Cr_6 is promoted from fourth to second.

Table 5.4.
Alternatives Cr_j in respect of attributes X_i given utility / importance weights W_i

	Generic discriminating factors: Attributes (X_i)											
	X_1		X_2		X_3		X_4		X_5			
	W_i	V_i	W_i	V_i	W_i	V_i	W_i	V_i	W_i	V_i	ACr_j	Rank
Cr_1	0.15	0.5	0.25	1.0	0.20	0.5	0.30	1.0	0.10	0.8	*0.805*	1
Cr_2	0.15	0.8	0.25	1.0	0.20	0.9	0.30	0.2	0.10	0.8	*0.690*	4
Cr_3	0.15	0.8	0.25	0.0	0.20	0.2	0.30	0.2	0.10	0.1	*0.230*	6
Cr_4	0.15	0.2	0.25	1.0	0.20	0.5	0.30	0.8	0.10	1.0	*0.720*	3
Cr_5	0.15	0.5	0.25	0.0	0.20	0.5	0.30	1.0	0.10	0.1	*0.485*	5
Cr_6	0.15	0.8	0.25	1.0	0.20	0.2	0.30	0.8	0.10	0.8	*0.730*	2

Obviously, in this latter example the decision maker might wish to further evaluate Cr_1 to confirm that this is the best alternative when bid value (£) is also considered. That is, would Cr_1 be 'best' if tender sum was *say* 10 percent higher than second ranked Cr_6? Does the extra cost indeed represent value-added when viewed in terms of a higher Cr_j score? In view of these questions it would appear that an all embracing evaluation, taking into account bid value as well as attribute evaluation, would be optimum.

5.4.1. Janssens (1992)

Janssens applied the elementary *additive* MAA approach to conduct design & build contractor evaluation. He advocated that subjective weightings be attached to the relevant selection criteria to mirror the practitioners perceived importance of each. The practitioner would then be able to award each contractor under review, a fraction or the whole of that weight, in accordance with perceived ability for the area under scrutiny. Figure 5.2. presents an example of his method. The concept of 'cut off' points is now also introduced (see also section 5.5.5. below).

5.4.2. Harris & McCaffer (1991)

Harris & McCaffer applied an MAA technique adopting the use of utility / importance weights to the problem of selecting an item of plant. They stated that the method forces the DM into a sequence of actions: the many separate judgments of which can be weighted and ranked accordingly. Subsequently, the best option can be chosen. A precis' of the steps involved are;

a) set objectives (identify selection criteria);
b) classify objectives - (perceived importance weight (ie., W_i) represented on a scale of say 1-10);
c) develop available choices;
d) evaluate each choice against each of the objectives and rate on a scale of say 1to10 (equivalent to V_i);

Figure 5.2.
Janssens' multi-attribute approach

Selection Criteria	*Maximum Weighting*	*Weighting Score awarded*									
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
General impression	10	6	9	5	7	8	7	4	2	4	2
Size	6	2	4	2	8	6	3	4	1	3	3
D & B Experience	20	18	12	15	5	1	16	12	8	7	10
Recent experience	10	5	6	5	1	4	8	4	3	4	5
Design experience	20	14	9	7	16	17	12	5	3	5	6
Office locality	10	3	7	4	6	6	5	9	1	3	8
TOTALS (Σ)	**76**	**48**	**47**	**38**	**43**	**42**	**51**	**38**	**18**	**26**	**34**

The scores may be ranked;

	Contractor	*Rank*
	F	51
	A	48
	B	47
	D	43 - eliminated - lack of recent experience
	E	42 - eliminated - lack of D & B experience
	C	38
	G	38
cut off line.	J	34
	I	26 - eliminated: below cut-off
	H	18 - eliminated: below cut-off

Contractors D & E are eliminated for specific failings within the contractor organisation, whilst contractors I & H are eliminated for being below the (26 points score) cut off line.

Adapted from Janssens 1992.

e) multiply the importance ranks (b) by the evaluation scores to (d) achieve the overall 'worth' of each choice.

The sum of weighted scores thereby highlights what should be the optimal choice. This method is superior to the previous investigated, in that each importance weight (b) becomes a coefficient for each criterion evaluation score (d). The resultant weighted scores (e), highlight the various merits / demerits of each potential choice.

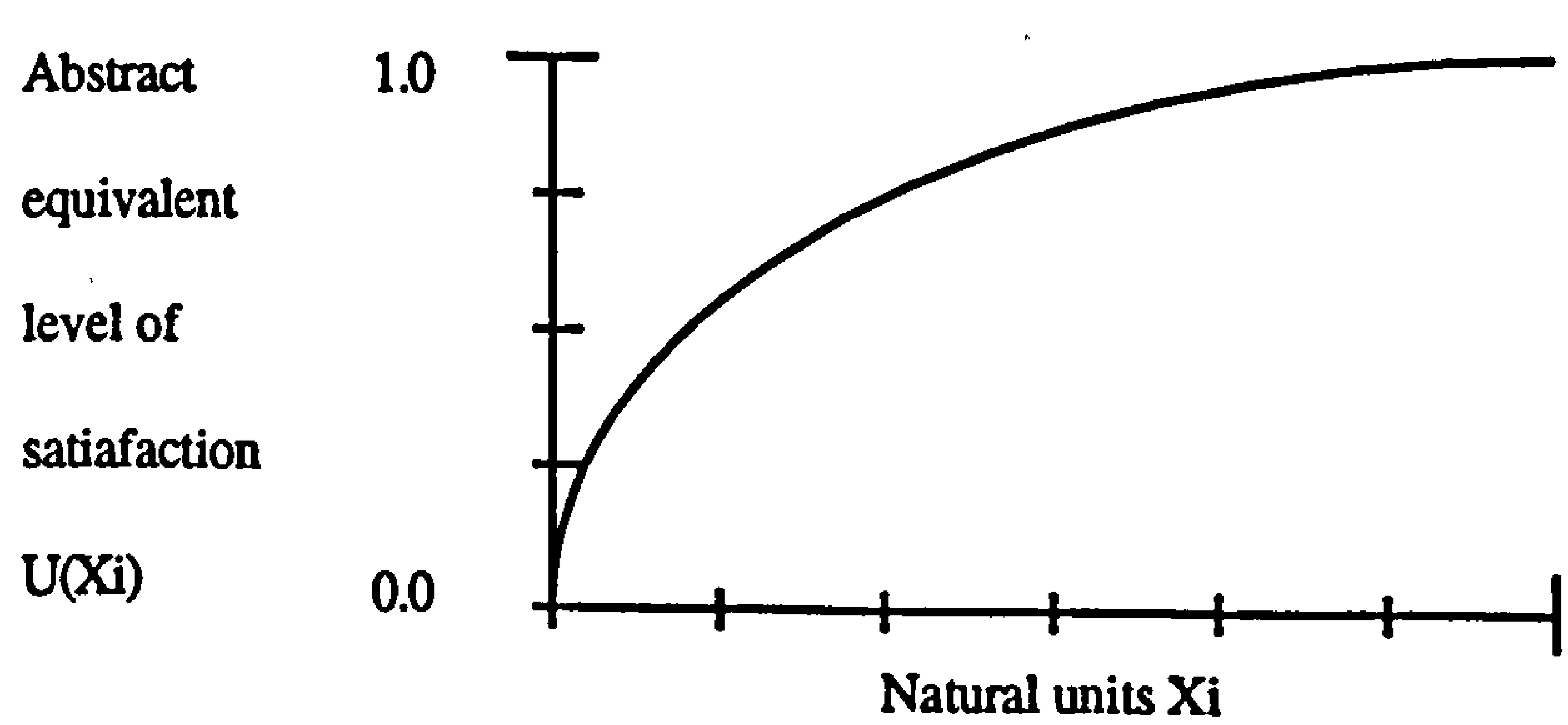
Furthermore, (e) is proportional to the practitioners' perceived importance of each selection criterion. This technique exhibits linear MAA characteristics.

In a similar vein to Janssens' application of cut off points, the use of 'musts' are included. A must is some objective that each potential choice *must not* violate, otherwise that choice is rejected forthwith. There is need for a similar component to be integral within the contractor selection model, in order to disqualify / reject those firms not meeting critical limits of past performance / financial stability etc.

5.4.3. Moselhi & Martinnelli (1981)

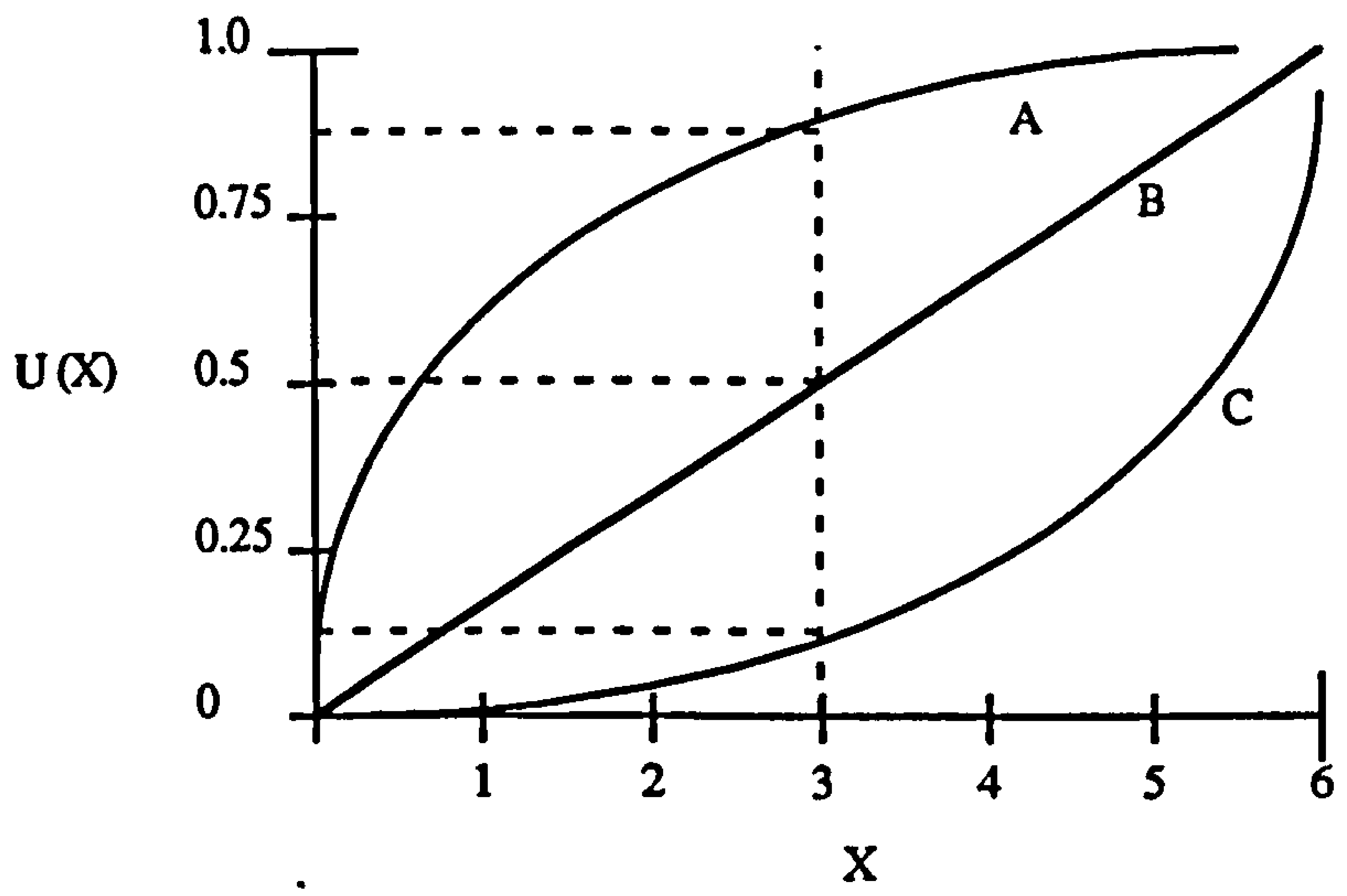
Here, the authors utilised multi-attribute utility theory (MAUT) to analyse construction *tenders*. Their approach demonstrates a specific variant of the MAA technique, in that the incommensurable units of the decision matrix are converted into common values (typically 0.0. to 1.0.) by application of utility curves -such values being expressed in *utiles*. Utility values may mirror an individual DM's utility of a particular original (incommensurable) value or, represent that of a particular sample (see Skitmore & Marsden, 1988). A basic utility function is shown in figure 5.3. Where the natural value (horizontal axis) intersects with the utility curve, then the corresponding value on the vertical scale is the utility score.

Figure 5.3.
Basic utility function



It is the DM's prerogative to adopt a risk seeking or risk averse approach to the decision problem, or indeed, to exhibit a neutral attitude. Such will be dependent upon the environment within which the DM is operating and physiological preference. Figure 5.4. depicts characteristic utility curves for each of these three types of DM.

Figure 5.4.
Characteristic decision maker utility functions



A = Risk prone. B = Risk neutral. C = Risk averse.

Assuming that the natural unit axis represents (say) number of past projects executed for a specific construction type then; contractor n having executed 3 such projects would achieve a utility score for each type of DM respectively of; A; Risk prone = 0.87, B; Risk neutral = 0.50, C; Risk averse = 0.12.

Moselhi and Martinnelli utilised the utility function technique to determine abstract values for each contractor attribute, which in turn are multiplicands of each respective attribute weighting. The selection model developed within this study does not adopt this same approach because;

a) attribute weightings were determined in the form of importance indices from the survey of selection practitioners (Chapter 4);
b) attribute scores are in the form of commensurate values being derivatives of attribute's natural values, as determined from respective attribute evaluation exercises (fully elucidated in Chapter 6).

However, as demonstrated below in section 5.6., because of utilitys' ability to take account of the DM's preferences it *is* embraced within the proposed selection model to provide dynamism ie., an input from the client will accommodate the characteristics of a *specific* project.

5.5. FOUNDATION FOR THE MODEL -A STEPWISE SELECTION LOGIC

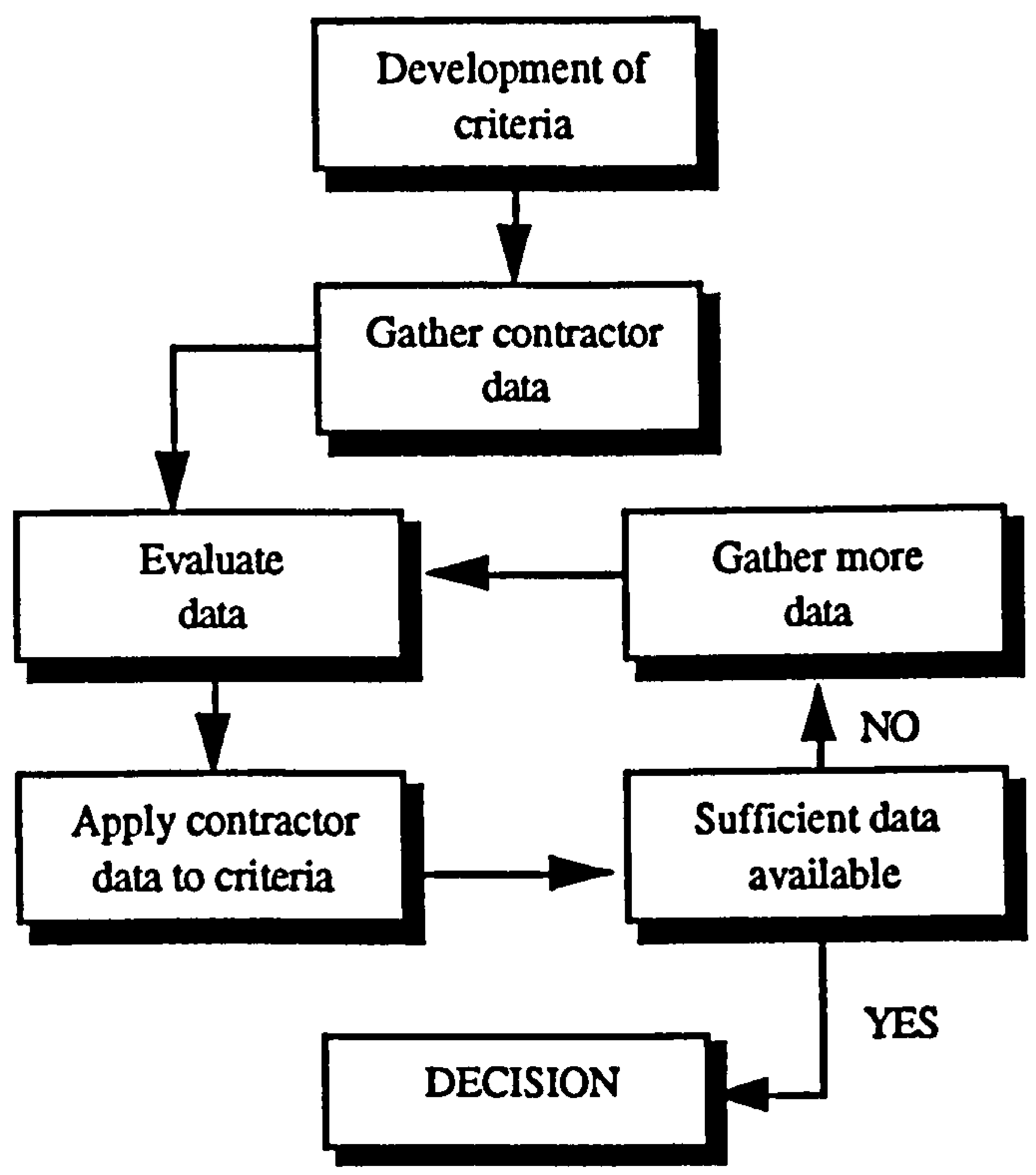
Having investigated the potential of MAA and ascertained the requisite mathematical characteristics of a new selection paradigm, a stepwise logic able to encompass the *entire* contractor selection process had to be identified. This could then serve as a framework around which to structure the model.

Russell & Skibniewski (1988) were concerned with the *prequalification* of contractors in the USA. They identified a 'generic logic' regarding the prequalification decision process in which the decision was binary ie., 1: prequalify contractor, 2: disqualify contractor.

The flow diagram in figure 5.5. reproduces their logic which was described as;

a) develop the selection criteria;
b) gather contractor data from sources;
c) evaluate the contractor selection data;
d) apply the data to the criteria;
e) gather more data if needed;
f) make the prequalification decision (yes / no).

Figure 5.5.
Flow diagram of the contractor prequalification process



Adapted from Russell and Skibniewski, 1988.

Albeit their work was confined to prequalification, the ratiocination served as a starting point for the required stepwise logic. Modification was performed to bring it into line, or more specifically, to encompass the *entire* UK selection process from identification of contractors desirous to tender, through to final selection choice. This more comprehensive, modified sequence is demonstrated under the eleven steps (a) to (m) below;

a) identify the selection criteria;
b) identify contractors desirous to tender;
c) gather prequalification data;
e) evaluate contractors and establish a shortlist (tenderers);
f) invite tenders from (e);
g) gather secondary investigative data from tenderers;
h) apply tenderer data to project specific criteria;
j) evaluate the results and establish a hierarchal list;
k) evaluate the bid component of tenders;
l) combine (j) and (k) to establish a final ranking of tenderers;
m) choose contractor.

Each component of this revised sequence is now discussed, in order that a complete picture of the necessary selection process may be established;

5.5.1. a) *Identify the selection criteria* -this was achieved in the preceding chapter. The results of the survey highlighting those discriminating criteria for inclusion in the model both at prequalification *and* tender evaluation stages. Generic prequalification factors are; *contractors organisation*, *financial stability*, *management resource*, *past experience* and *past performance*. Project specific attributes are applicable only to those contractors tendering. Referral to Table 4.12. will refresh the reader of *all* selection criteria included.

5.5.2. b. *Identify contractors desirous to tender* -the most effective means of achieving this is via advertisement (Merna & Smith, 1990). (The advantages of free competition achieved by advertising for contractors was highlighted as early as 1944 by The Simon Committee). A press announcement is the most obvious route (F.I.D.I.C.,

1980) although direct approach to firms of known repute need not be ruled out. A regular employer may wish to consult his own list of 'approved' contractors but under this new technique previously 'approved contractors' will need to *reapply* for prequalification.

Whatever means is employed, the advertisement at this stage should specifically invite contractors to "apply for invitation to prequalify". As Merna & Smith confirmed, the use of an advertisement has two distinct advantages;

a) it generates a response from only those contractors who have a genuine interest in undertaking the works and subsequently should lead only to submission of bona-fide bids -so long as the tenderers are chosen from successfully prequalifying respondents of the advertising exercise;
b) advertising is perceived as the fairest method, allowing any interested party to request that they be considered for prequalification. This eliminates the possibility of complaints as contractors not responding cannot complain at being omitted!

5.5.3. c) *Gather prequalification data* -presently, the use of a structured questionnaire is by far the most common method utilised -see sample under Appendix E. Questionnaires need not be dispensed with because they have proven their purpose over time. However, the advent of a computerised (expert) contractor selection system would inevitably mean a transition to data-collection by diskette. "It is envisioned that as real time data-collection technology advances and becomes more cost effective, all relevant data will be collected in this manner" (Russell, 1992). The diskette method reduces the volume of work required of contractors in supplying data but more importantly, would rationalise the entire collection and data processing function for the practitioner.

5.5.4. d) *Apply the data to prequalification criteria* -data supplied must be evaluated in comparison to the criteria applicable. Exact methods of achieving this are detailed in chapter 6. It is ultimately envisaged that an expert system combined with diskette data collection, will provide for ease of evaluation whilst also allowing large numbers of contractors to be prequalified in a relatively short space of time. This is in contrast to present methods which tend to rely on long hand analysis and are therefore time consuming.

5.5.5. e) *Evaluate results and establish a shortlist of prequalified contractors* -an overall scoring method is desirable to facilitate a comparison of contractors relative to each other but also, elemental analysis is required to look for signs of *specific weakness* in the contractor. This will firstly identify a contractor who achieves a reasonable overall (aggregated) score but nonetheless exhibits poor performance potential in specific area/s. Secondly, this approach would help in segregating firms where an overlap of clusters (good / not-so-good contractors) occurs. Such weaknesses would need further investigation and may lead to disqualification of the contractor. This is where there is scope for introducing cut off points (Janssens, 1992) that is, predetermined minimum score(s) below which automatic disqualification comes into effect.

Contractors successfully completing prequalification may then be ranked according to their overall score. If n contractors are the number required to tender then theoretically, the largest n scores are the prime candidates. The ideal number of contractors to be invited to tender has been the subject of much discussion and debate (Merna & Smith, 1988). Current practice suggests that tender lists should not be allowed to grow too large and that fair competition is most likely to be achieved, when a final selection of four to six tenderers is established. A method whereby the optimum number of bids is calculated on the value of the work to be done, has been devised by Beeston (1983).

With regard shortlisting, the writer contends that the (albeit somewhat subjective) intuition of the experienced selection practitioner, should not be totally discounted at this stage. It seems folly not to combine such accrued knowledge and traditional wisdom, with quantitative analysis.

5.5.6. f) *Invite tenders* -*n* firms having successfully prequalified may be furnished tender documents. It is worth mention at this stage that several authors stress the importance of supplying contractors with a comprehensive standard portfolio of documents upon which to compile their bid; (N.J.C.C., various; I.O.B., 1979; Merna &Smith, 1988; F.I.D.I.C., 1982; I.C.E., 1980). This consensus of opinion suggests that the portfolio should include specification, bills of quantities, contract (form) details, nomination details and anticipated programme / critical completion dates.

5.5.7. g) *Gather secondary investigative data from tenderers* -as highlighted in Chapter 3 there is currently a lack of secondary investigation into firms tendering as a means of assisting the practitioner during tender evaluation. Under the new selection method prequalification will investigate contractors in light of more general, organisational criteria. Secondary investigation requires more specific evaluation; "project specific criteria can evaluate if a candidate contractor will provide unusual expertise or specialist facilities required by the project" (Russell, 1992). The necessary contractor data for this secondary evaluation can be requested from tenderers at the time of their being furnished tender documents (f above). The comments therein regarding data collection equally apply here also.

5.5.8. h) *Apply data to more specific criteria* -evaluation is required in light of the 'project specific' and 'other specific' criteria determined earlier (refer Table 4.12.).

5.5.9. j) *Evaluate the results and establish a hierarchal list* -tenderers may be ranked on the basis of their secondary evaluation results, with the comments regarding cut off points applying here also. The ability to rank tenderers at this stage (which has not yet considered bid values) is evidence of a much broader evaluation technique (vis-a-vis current methods) being implemented.

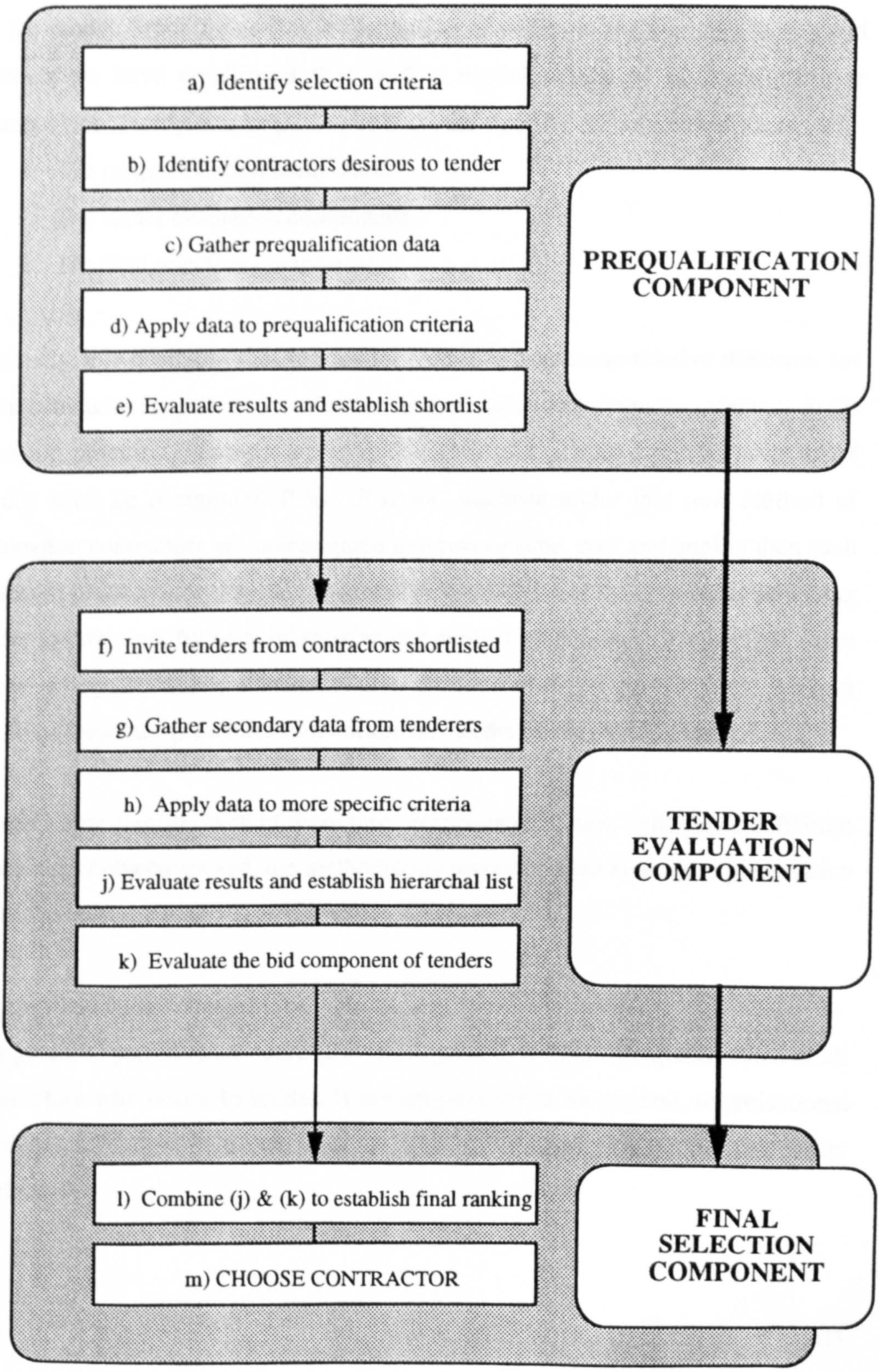
5.5.10. k) *Evaluate the bid component of tenders* -tender submissions are easily ranked on the basis of their monetary value. However, if procedure allows for the submission of qualified bids it is at this time that they need to be brought onto a common basis for objective comparison. Furthermore, where tenderers are allowed to state proposed contract period and / or the magnitude of any advance / mobilisation payments (see Hawwash, 1991), then time / value analysis of bids may be performed at this stage using discounting techniques (Vorster, 1977; Smit, 1978; Hawwash, 1991; Mott, 1992). An example of discounting within the framework of the model is given in chapter 7.

5.5.11. l) *Combine (j) & (k) to establish a final ranking of tenderers* -a quantitative numerical amalgam of a contractors performance potential (ie., secondary evaluation) *combined* with financial attractiveness of the bid will identify the best all round contractor for the job.

5.5.12. m) *Choose contractor* -a selection process utilising the comprehensive analysis described above will facilitate easier selection ie., the contractor exhibiting most performance potential in terms of time, cost *and* quality.

The above stepwise logic and its relationship to the overall selection process is presented in Figure 5.6. Besides being a basis for the mathematical model, this rational approach to the decision problem also addresses the weaknesses that are inherent within current selection practice (chapter 3).

Figure 5. 6.
Framework for the model - a stepwise logic



5.6. CONVERSION OF THE LOGIC -AN ALGORITHMIC MODEL

The sequential logic derived above must now be incorporated within the mechanics of the model. From the earlier investigation of decision making approaches and models we have confirmed that such a model would be of multi-attribute composition. Firstly, it is helpful to confirm the three basic functions of the model:

1. The prequalification component;
2. The tender evaluation component;
3. The final selection component.

Secondly, it is desirable that the model furnishes a numeric relative measure, for each contractor subjected to evaluation to serve as an unambiguous reference in the decision process. This measure is in the form of a potential performance score which shall be designated P ie., *P score*. Because under this new method of evaluation contractors are investigated in terms of time, cost and quality then such potential performance may be perceived in the context of the contractor achieving client satisfaction, by way of satisfactory project performance for each of these superlative performance standards - *time cost and quality.* At this stage, we may combine these two principles and outline the model as shown in figure 5.7.

We may now describe each of these three components in turn, to facilitate definition of the aims / objectives and, the methodology involved. Mathematical representation is also given.

5.6.1. Prequalification component -P1 score

The potential performance score (P1) is designed to facilitate prequalification of all contractors who desire to tender. It investigates the more general, organisational attributes of a contractor company in light of the discriminating criteria earlier confirmed.

Figure 5.7.
First principles of the model

Logical stage of model	*Identification within model*	*Component purpose*	*Method used*	*Models output*
Prequalification component	P1 analysis	Identify contractors for invitation to tender	MAA[1]	Rank / %
Tender evaluation component	P2 analysis	Furnish extra dimension in tender evaluation	MAUT[2]	Rank / %
Final selection component	P3 Score	Identify 'best' contractor for award of contract	Algorithm[3]	Rank / %

[1]*Multi attribute analysis (cf. Hwang & Yoon, 1981).*
[2]*Multi attribute analysis and utility theory (cf. Skitmore & Marsden, 1988).*
[3]*P3 is a numerical amalgam of P2 score and tender sum (see chapter 7).*

In it's simplest form, P1 replaces the traditional pre-selection task currently performed as a means of establishing a select list and instead, incorporates prequalification as an *essential and integral part of the overall selection process.* Unlike current prequalification procedures (performed by differing client organisations with an over reliance on subjective measures) P1 score is an objective measure of the up-to-date performance potential of a contractor.

Theoretically any number of contractors can be assessed and awarded a P1 score. Furthermore, there is scope for the experienced client with an on-going construction programme to develop an history of P1 scores. These would serve as a retrospective indicator of contractor's past performance and corporate stability trends. Mathematically, P1 may be expressed as;

$$P1 \ score = \frac{Z1_j}{Z1\,Max}$$ where;

$Z1_j$ = score achieved under P1 analysis for contractor $_j$ and is determined via the formula;

$$Z1_j = \sum_{i=1}^{21} V_{ij} W_i$$ when;

21 = twenty one discriminating criteria attributed to P1 analysis
V_{ij} = variable scores achieved by contractor $_j$ for each criterion $_i$
W_i = importance weights attached to V_i.

Z1Max is the maximum attainable Z score under P1 analysis. Because the maximum V_i value is 1.0 then: $Z1Max = \sum W_i$ (i = 1, 2, ...21).

It can be seen therefore that a contractor who was to attain a maximum score in all variables V_i (i = 21) would achieve a P1 score of 1.0 which may be expressed in terms of 100 percent potential performance score. Accordingly, a contractor obtaining an average score of half could be expressed as having a 50 percent potential performance score, and so on. It is to be noted that these are *aggregate* P scores, but one must not overlook that a good aggregate score may have been achieved by a contractor compensating poor V scores, with good scores in other variables. Hence, factor scores (score achieved amongst a given set of variables) may be derived and checked.

Factor scores are achieved via the formula;

$$\text{Factor score} = \frac{\sum \text{rationalised variable scores for given factor}}{\sum \text{ weighting indices for the same variables}}$$

where rationalised variable scores are determined from;

1. V score x respective weighting index (for any given P1 variable);
2. V score x respective weighting index x respective utility value (for any given P2 variable).

It is the actual checking of these factor scores that will address the problem of overlapping clusters and specific weaknesses described above. This is clearly shown in the worked example of the technique in Chapter 7.

5.6.2. Tender evaluation component -P2 score

P2 broadens the evaluation of those contractors who subject to satisfactory P1 analysis have been invited to tender, again by yielding a potential performance score (P2). The theme is for P2 evaluation to be conducted at the same time as contractors are compiling their bids, thereby furnishing the practitioner with this extra dimension by the time formal tenders are received.

As per P1 analysis, this secondary investigative component also employs a number of discriminating criteria, but these are much more specific to further assess the tenderer *in light of the proposed project*. In addition, a utility weighting is included making use of Multi Attribute Utility Theory (see Moore & Thomas, 1979; Skitmore & Marsden, 1988; Moselhi & Martinnelli, 1990).

If the practitioner / client is indifferent to all possible outcomes and is willing to accept their effect regardless, then weighted criteria alone are an appropriate decision technique. However, utility allows the owners perception of performance dimensions to be attached to each discriminating criterion thereby *making the selected contractor reflect the clients preference as much as possible.*

Chapter 7, in elucidating a fully worked example of the new technique, expands on the utility concept and confirms that a contractor exhibits greater potential for achieving client satisfaction, whose best attributes correlate with those criteria perceived as important (ie., have a higher utility value) by the owner. Simultaneously, utility renders the model dynamic by responding to the specific circumstances pertaining to a given project -and, the owners perception of a successful outcome. Utility weight extrapolation will be performed in a similar fashion to that shown in Figure 5.4. earlier.

(The use of the utility curve is not to transpose an attributes natural units to utiles (cf. Moselhi & Martinnelli 1990). The model achieves this by separate evaluation exercises. Rather, utility is used to reflect a practitioners perceived level of importance (impact) of an attribute on the potential success of the proposed project).

It could be argued that P2 factors should be considered at the pre-tender stage (ie., P1 analysis) since it seems reasonable to assume that the more attributes evaluated the greater reliability can be placed on the outcome? Well this is not the case because P1 analysis concentrates on the more important fundamental aspects of a firm. Therefore, if a contractor is failing on such important P1 factors (as say) *financial stability* or *lack of resources* then P2 analysis is irrelevant. Mathematically P2 score may be expressed as;

$$P2\ score = \frac{Z2_j}{Z2Max} \quad \text{where;}$$

$Z2_j$ = score achieved under P2 analysis for contractor $_j$ and is determined via the formula;

$$Z2_j = \sum_{k=22}^{29} V_{kj} W_k U_k \qquad \text{when;}$$

22..29 = the eight discriminating criteria attributable to P2 analysis
V_{kj} = variable scores achieved by contractor $_j$ in respect of attribute $_k$
W_k = importance weights attached to V_k
U_k = utility weights attached to V_k by practitioner / client.

Z2Max = maximum attainable Z score under P2 analysis. Because V_k and $U_k \leq$ 1.0 then; $Z2Max = \sum W_k \quad (k = 22, 23, \ldots\ldots..29)$.

5.6.2.1. Calculation of P1 and P2 variable scores

Within the model, selection variables of like nature are grouped under generic heads: factors. Each group of variables attributed to each factor are evaluated by way of several sub-variables. Figure 5.8. demonstrates this concept.

P1 analysis consists of five factors, twenty-one variables and a possible sixty-five sub-variables. P2 analysis evaluates two factors, eight variables and twenty possible sub-variables. There is future scope for the number and nature of variables to be varied and / or broadened, to placate the requirements of alternative selection situations such as differing procurement forms.

During both P1 and P2 analysis a score between zero and 1.0 is ascertained for each contractor in respect of each variable, by measuring the firm against each variables' sub-variables. Mathematically, variable scores are calculated by;

$VX_j = Svx_{1j} + Svx_{2j} \ldots Svx_{nj}$ where;

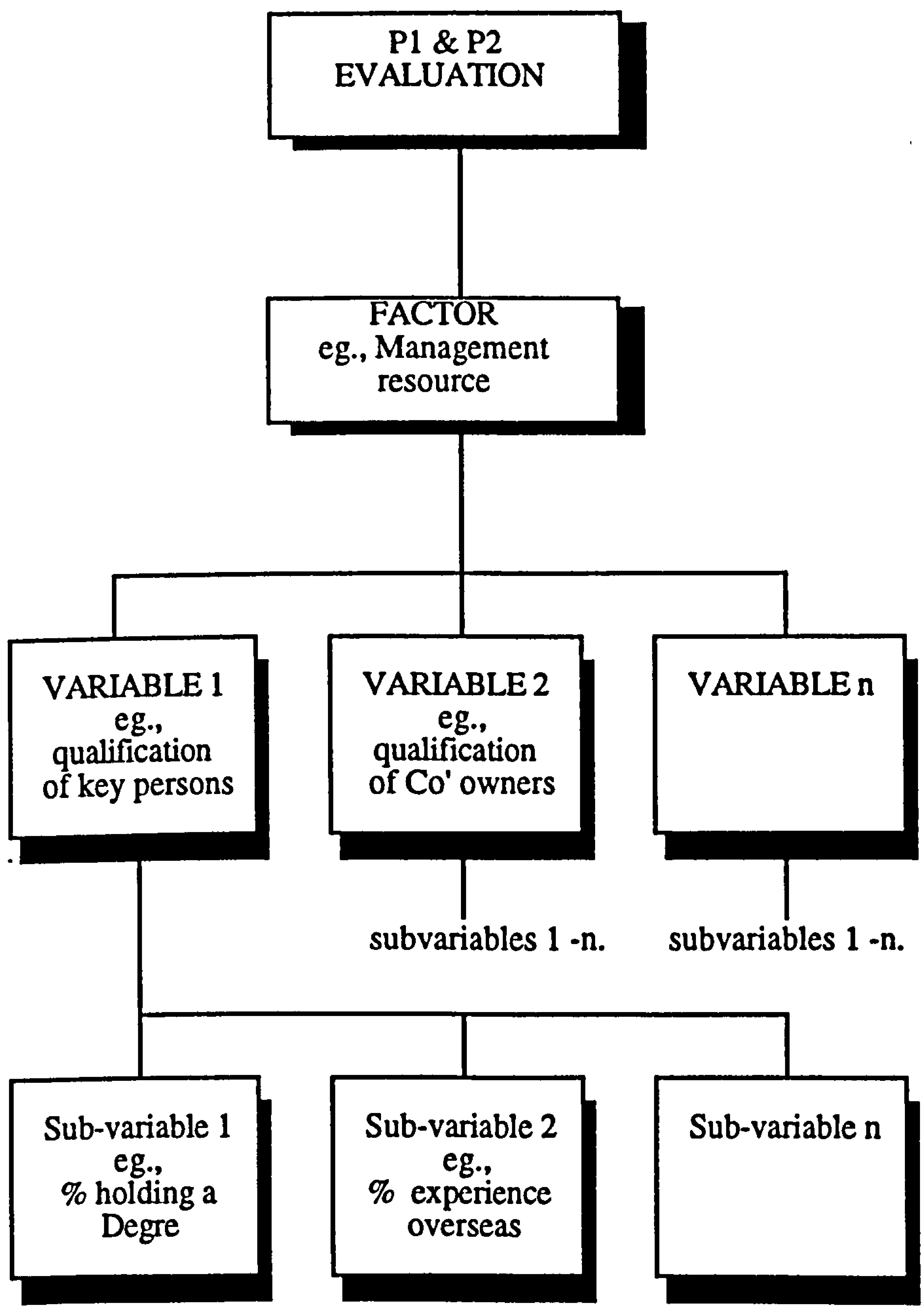
VX_j = variable X score for contractor $_j$

$Svx_{1j \ldots nj}$ = sub variable scores attributable to variable X for contractor $_j$

However a constraint exists in that; $\sum Svx_{1j} + \ldots\ldots + Svx_{nj} \leq 1.0$.

At this time sub-variables are equally weighted ie: $Svx_{nj} = \frac{VX_j}{n}$

Figure 5.8.
The concept of factors, variables and sub variables



5.6.3. Final selection -P3 score

P3 is an amalgam of project specific P2 score and tender sum to arrive at a final selection ranking. Previous works have demonstrated that both construction owners and contractors rank cost as the most important factor in the winning and awarding of contracts (Baker & Orsaah, 1985; Merna & Smith, 1990). It is reasonable therefore to assign greater weight to tender sum than P2 score. Within the model this is initially proposed as 60 percent cost, 40 percent P2 score -proportions in agreement with work done elsewhere associated with tender analysis (Hawwash, 1991B). However, individual clients may wish to determine this balance for themselves (see also sensitivity analysis Chapter 8).

Mathematically P3 score may be expressed as; P3 score $= 0.6\,(BS_j) + 0.4\,(P2_j)$
where: BS_j = bid score for contractor j and is determined via the formula;

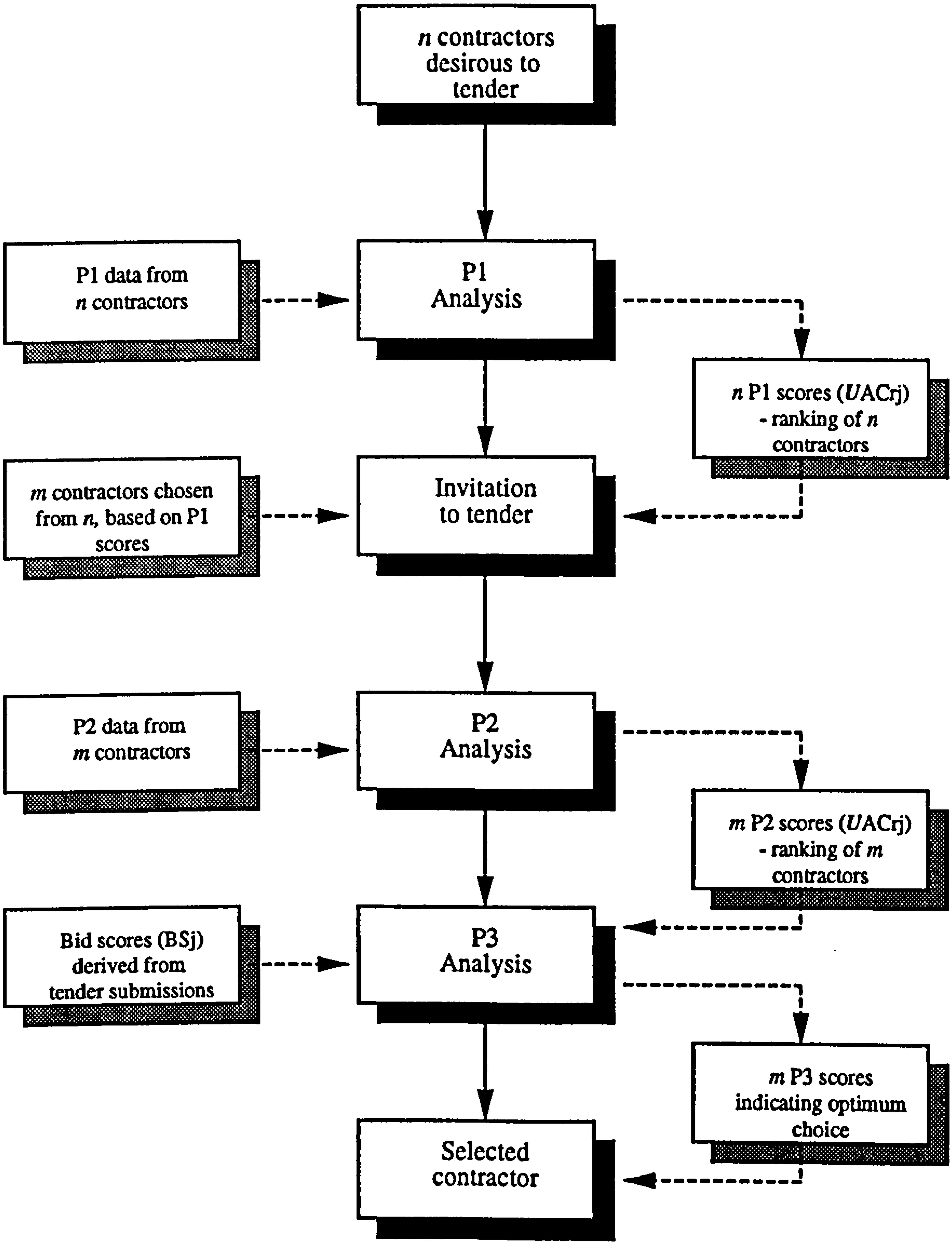
$$\text{Bid score} = \frac{\text{Lowest tender submitted (£) for this project}}{\text{Tender submitted (£) for this project by contractor } j}$$

$P2_j$ = P2 score for contractor j expressed as a decimal.

Calculating bid scores in this manner is based on the sole criterion of net value. However, for large projects or where contract duration is at the contractors discretion, the owner may wish to broaden the analysis by considering the time value of capital (in such instances the lowest bid may not be best return on the investment since it represents a series of payments over time). Chapter 7 in presenting a worked example of the model shows how discounting techniques may be employed to overcome this.

Finally, Figure 5.9. demonstrates the relationship of the above model components with regard the overall selection process. The relationship of mathematical inputs / outputs is also shown.

Figure 5.9.
Relationship of the model to the overall selection process



5.7. SUMMARY

Designing a contractor selection model was essentially a mission to create a decision tool, as evidenced by there being more than one course of action available to the practitioner.

The need for decision aids arises out of the conjunction of limited human rationality and the processing demands of complex decision situations such as the contractor evaluation / selection scenario.

The most suitable method for this decision problem is that of multi attribute analysis. This is because MAA addresses the (often conflicting) multi criteria nature of real world decision making. The utilisation of utility theory also facilitates the incorporation of decision maker preferences in computing the 'best' solution.

Based on a stepwise logical sequence of operations necessary to complete rational contractor selection, a three stage process was developed. This three stage model aids the decision maker by furnishing potential performance scores (in the context of satisfactory project performance by the contractor) at three crucial stages of the selection process;

Stage 1	P1 score: prequalification of contractors desirous to tender;
Stage 2	P2 score: evaluation of tenderers;
Stage 3	P3 score: final selection choice.

CHAPTER 6

EVALUATING CONTRACTOR ATTRIBUTES

6.0. INTRODUCTION

This chapter describes the research and points of reference that ascertained necessary methods of evaluation, for each of the discriminating criteria assigned to the model. This facilitates appraisal of contractor's in respect of each criterion (variable), specifically, to establish a variable score (V_i / V_k) where: $0 \leq V_i / V_k \leq 1.0$. These objective functions may then be incorporated into the model. The Chapter also introduces pro-forma evaluation documents developed for such evaluation namely;

a) Prequalification (P1) analysis sheets;
b) Prequalification (P1) summary analysis sheets;
c) Tenderer evaluation (P2) analysis sheets;
d) Tenderer evaluation (P2) summary analysis sheet (Appendices F to I).

Having identified required input data (ie., necessary contractor information to achieve the analyses) the exercise also moulds prequalification and, tenderer evaluation questionnaires. These are introduced during the worked example that follows in Chapter 7.

6.0.1. Criteria identification

Contractors must be analysed in respect of the criteria (1, 2,.., 29) identified in Chapter 4. These criteria encompass a broad evaluation with most requiring several modes of investigation. It will be recalled that this is achieved via analysis of each variable's *sub-variables* (section 5.6.2.1. & Fig. 5.8). Therefore, a method of variable / sub-variable identification is now established in order that each criterion score may be distinguished and cross referenced hereafter.

As an example, consider criterion number 7, *Ratio analysis of accounts.* The variable itself is prefixed by *V* ie., V7. Each sub-variable attributable to V7 (a, b, ..,n) is succeeded by a lowercase letter. See Table 6.1.

Table 6.1.
Criteria identification

Identification	Classification	Comment
V7	(variable)	Variable 7: ratio analysis of accounts.
V7a	(sub-variable a)	sub-analysis **a** (current ratio score)
V7b	(sub-variable b)	sub-analysis **b** (current ratio trend)
:		
V7n	(sub-variable n)	sub-analysis **n**

The following discussion looks first at prequalification, then tenderer evaluation variables / sub-variables. All are identified in the manner described above, this identification also being common to data collection / evaluation documentation.

Albeit V_i / V_k analyses are broad in scope, certain elements of analysis are difficult to quantify. The evaluation of sub-variables aims to offset this as far as possible. For example, perception of *corporate image* is implicit and hence subjective, so here, enquiry is made as to a contractors membership of *image improving* trade associations. Unfortunately, this subjective component will be incessant within the model due to its multi-attribute character; "the distinguishing feature of multi-attribute decision making is that the attributes may not necessarily be quantifiable" (Hwang & Yoon, 1981; Holt et al., 1995B).

6.1. EVALUATING P1 VARIABLES

6.1.1. V1: Size

Company size may be defined in several ways: total assets, net assets, turnover, number of employees etc. For comparison purposes net assets is a common yardstick eg., D.T.I. classification, lists of companies, Companies House. An optimal definition for selection practitioners would be a comparison measure, capable of matching contractors of a given 'size' (resource capacity) to projects of a compatible resource requirement. However, the varied nature of construction means possible permutations of project size and value are innumerable. Furthermore, it has become clear during this research that no *simple* measure of contractor capacity exists.

Firstly therefore, a measure of resource capacity is required. Formulas to determine this *Maximum Financial Capacity* (MFC) are commonplace in U.S. departments of transportation, exhibiting a variety of forms;

a) current assets multiplied by a co-efficient (eg., 10);
b) current assets minus current liabilities multiplied by a co-efficient;
c) net worth multiplied by a co-efficient (Russell et. al, 1992).

Their most apparent failing is the need for a subjective co-efficient, minor error in which is magnified because of the multiplier effect inherent within the equations. A more quantitative formula identified is of the form;

Maximum Financial Capacity (MFC) = M([CA-CL] + [0.5(NCA)] - NCL) where;

M = *Modifying coefficient*
CA = *Current assets*
CL = *Current liabilities*
NCA = *Non current assets*
NCL = *Non current liabilities* (ibid).

Constituents of the formula are readily accessible from a company balance sheet. A point of contention may be the valuation of fixed assets, which may be defined as either;

a) *Tangible* -normally land, buildings and machinery;
b) *Intangible* -'unreal' in the physical sense such as patents, trade marks, copyrights and goodwill.

Both should be included within the equation because each contribute toward company ability to earn profit (Parker, 1988). Regarding valuation of fixed assets they may be stated in the balance sheet at;

a) *historical cost* -the amount paid by the investor when an asset was acquired and conforms to conventional accounting techniques;
b) *current cost* -the value of fixed assets adjusted to allow for inflation utilising either 'current purchasing power' or the 'current cost accounting' technique.

Attempts to introduce inflationary accounting have been beset by many difficulties (Parker, 1988). It seems most unlikely that historical costing will be replaced by a system of accounting for price level changes (Pizzey, 1990), so fixed assets are normally shown on the balance sheet at historical cost less depreciation. (Some companies revalue their fixed assets periodically as to reflect changes in value.

However, in such cases asset values may soon become outdated again.) Within the model fixed asset values at historical cost are utilised because;

a) adjustment of asset values (current cost) is a complex and time consuming task;
b) although maybe not entirely representative of fixed asset base *value*, in view of historical cost accountings' peculiarities, figures on the balance sheet are prudent. Any surplus between actual value and value stated could serve as a 'contingent' in the sense that it is available for loan security if needed!

The MFC formula is best explained by example. Assume the following figures have been extracted from a contractors accounts;

Fixed assets:	tangible	£1,700,000	
	intangible	£ 100,000	
			£1,800,000
Current assets:			£ 650,000
Liabilities falling due < 1yr:			£ 300,000
Liabilities falling due > 1 yr:			£ 300,000

Then MFC = [(650-300) + (0.5 x 1800) - 300] = M(£950K). This *gross* MFC figure of £950K is adjusted via the modifying co-efficient, because, for a company to remain in business it must be committed to *some* work-in-progress. Therefore, if present workload is subtracted from gross MFC the remainder (ie., *net* MFC) will represent approximate vacant capacity. 'M' is proposed[1] as 0.5 thereby leaving half of gross MFC as vacant. Hence: 0.5(950) = £475K (*current workload at time of tender evaluation* is more accurately calculated under P2 analysis -see V27 later).

In order that net MFC may be compared with the demands of the proposed project, Maximum Financial Outlay (MFO) is now calculated. MFO may be defined as the

[1] M may otherwise be determined by the practitioner in light of prevalent construction demand.

maximum outlay for the project that the contractor must be committed to, without payment, at any one time.

A linear relationship between expenditure and time is assumed, because to calculate the 'S' curve ie., cumulative cashflow commitment (see Vorster, 1977; Smit, 1979; Hawwash, 1991A) would prove impractical for what is a 'small' element of a large overall evaluation (refer cost of information Figure 5.1). Assuming the following figures;

proposed project value (in-house estimate)	£1.6M
proposed project duration	9 months

then, using our linear approach £1.6M/9 requires £178K outlay per month. Because payment delay is normally one month (cf. JCT, various) approximate MFO required for the proposed project[2] is £178 x 2 = £356K MFO. In this example, MFO < MFC and would therefore be acceptable -hence a maximum score of 1.0. Where MFO > MFC the firms ability to commit resources to the project is questionable and subsequently scores zero.

In summary, evaluation requires abstracted figures from the contractors most recent balance sheet and the clients estimate of proposed project value / contract duration. The MFO formula may be adjusted where payment delay is other than the usual one month ie., MFO = 2(project value/interim payment period).

6.1.2. V2: Age

Company age has bearing on company status in that a mature business exudes an aura of stability, reliability and accrued experience. So much so, age is often employed to help project a steadfast corporate image particularly when advertising;

[2] Maximum 2 months without payment.

"Established since 19...." Until recently the relationship between age and corporate stability was to a greater extent probably true. However, macroeconomic decline of the early 1980's combined with recession at the turn of the 1990's, has had a severe effect on the construction sector. Contractor's prudent financial management of the past has all but been exhausted -evidenced by numerous mature construction company failures in recent years.

Indeed, figures from the Annual Abstract of Statistics (C.S.O., 1992; 1993) show company insolvencies to have increased by 20 percent whilst bankruptcies and deeds of arrangement have increased by almost 300 percent (C.S.O. 1992).

In light of this trend the confidence once generated from a long trading history can no longer be relied upon as a measure for the future. Rather, evaluation should establish whether a company has traded for a minimum period -during which time it will have been suitably 'tested' in its ordinary market environment. Observation has shown the most appropriate time period to be three years.

In observing this minimum trading period it is prudent to attach two qualifications;

a) *in the construction sector* -for obvious reasons;
b) *under the same company name* -successive re-registering of companies after continued failure does not amount to the type of experience that clients desire!

Further qualification is unnecessary because other factors including corporate image, litigation tendency and client references are evaluated later. Compliance with this three year period is scored 1.0. Because there is no 'middle ground' a zero score is awarded where this is not the case.

6.1.3. V3: Image

Image is implicit, a difficult phenomenon to quantify. Company image may be perceived as good by one party but not so by another -it is a subjective area to evaluate. Nonetheless, company membership of professional associations is a means of image improvement and therefore measurement, as confirmed by the C.I.O.B. Chartered Company Scheme; "By enabling professional managed companies to use the title *Chartered Building Company* the scheme provides considerable help in improving the image of responsible building companies[3]". (C.I.O.B., 1992). Horgan (1987) stated that identification of trade associations to which a company belongs is a necessary attribute to be determined in any prequalification exercise.

A contractor is awarded a score commensurate with company membership of such organisations. Some prominent construction organisations include;

a) Chartered Building Company Scheme (C.I.O.B., 1992);
b) Building Employers Confederation (B.E.C., 1992);
c) The Federation of Civil Engineering Contractors (F.C.E.C.,1992);
d) Confederation of Construction Specialists (Henderson & Henderson, 1992)
e) Federation of Building Specialist Contractors;
f) Federation of Master Builders;
g) The National House Building Council (ibid).

Some contractors have a specialist bias so company membership will reflect this. For example, a firm prequalifying for a local authority housing contract, may be a member of both (a) and (g) above. Alternatively, a civil engineering contractor prequalifying for highways and bridge works might be a member of (c) and (d).

A score of 0.5 is available for each of two association memberships deemed by the

[3] Liaison with selection practitioners of late has confirmed that the scheme is almost a prerequisite for admission to many standing lists.

practitioner as worthy of image improvement, bearing in mind the nature of the proposed project.

6.1.4. V4: Quality control policy

Initially it is useful to observe some relevant definitions;

Quality: "The totality of features and characteristics of a product or service that bear upon its ability to satisfy a given need.

Quality Control: The operational techniques and activities that sustain the product or service quality to specified requirements.

Quality Assurance: All activities and functions concerned with the attainment of quality" (B.S. 4778).

Quality is a function of all company activities that influence the completed product and therefore needs broad evaluation to adequately investigate *quality control policy*. Fortunately, a measure exists which achieves this in the form of British Standard 5750 (B.S., 5750) or the international equivalent: ISO 9000 (see also B.S.I., 1990).

Quality Assurance (QA) has only come to the fore within the construction industry during the last decade, its beginnings are associated with other sectors of industry, in particular engineering (Griffith, 1990). QA *is* being adopted by the construction sector albeit at a gentle pace, probably because conformity to quality standards is a voluntary undertaking influenced in the main by company philosophical and commercial interests (ibid). Q.A. may be measured via three types of assessment;

a) *First party* which involves the setting up of a quality system followed by internal evaluation or QA audit. Guidelines for such have been produced by the C.I.O.B. (1989);

b) *Second party* which facilitates an input from the client, to meet specific product needs;

c) *Third party* which is a comprehensive independent evaluation and registration under the guidance of B.S. 5750.

Griffith (1990) confirmed that (c) eliminates the need for multiple assessments.

B.S. 5750 is the national standard for QA systems, superseding earlier quality standards (eg., BS 4891). It informs those responsible for quality arrangements, what is required of the system (Atkinson, 1987). The comprehensive six part document promotes formulation, development and implementation of a formal, workable QA structure to attain BS5750 certification. If successful, this means that third party quality assurance assessed against the BS 5750 framework has been achieved. Because;

a) adoption of QA is presently voluntary so where implemented would indicate a genuine desire to attain consistent quality;

b) where BS 5750 certification exists full third party assessment has been successfully achieved indicating that satisfactory QA procedures are in place.

Certification may be used as the yardstick to evaluate this variable. Full credit is given where certification exists ie., score = 1.0, but the intention to register is an indicator of a positive QA attitude and is subsequently scored 0.5. Where neither of these situations apply a zero score is awarded. In short, evidence of BS 5750 certification or confirmation of the intention to register within the next six months is required of the contractor.

6.1.5. V5: Health and safety policy

From the contractors standpoint, health and safety (H&S) in the workplace is promoted and enforced by The Health & Safety At Work Act 1974 (HASWA 74), applicable throughout Britain. Under the Act three prime areas of duty exist;

a) the duties of employers to employees;
b) the duties of employers to people other than their employees;
c) the duties of employees to themselves *and* other persons (HMSO, 1990).

All three have some bearing on company H&S performance but in this context (a) and (b) require most attention. The Act details that employers must provide;

- safe plant / equipment and safe systems of work
- that particular machinery and substances must be handled, stored, used and transported in a safe manner
- for all employees; information, instruction, training and supervision necessary to ensure H&S at work
- that any place under their control must be in a safe condition
- a healthy working environment.

In addition, employers (excluding exemptions ie., undertakings employing less than five persons) must conform with section 2(3) of the Act and formulate an internal safety policy. The purpose of the safety policy is to ensure that employers think carefully about the nature of hazards at the workplace. The policy statement must set out employer aims and objectives for improving H&S at work and increase employees awareness of policy and arrangements for safety (HMSO, 1990).

The Health & Safety Executive enforce HASWA 74 their representatives being appointed inspectors. Inspectors may issue notices backed up by law requiring action to improve standards or prevent accidents. *Improvement notices* require the offender to remedy an H&S contravention within a set time limit. Where a risk of serious personal injury exists or an improvement notice has not been conformed with, a *prohibition notice* may be served -prohibiting the work activity until such risk is removed. Establishing whether a contractor has been served with either notice over the last five years will identify any serious H&S failing.

Scoring for the model is achieved via ten questions, each potentially worth 0.1. Combined they probe the extent of H&S implementation / history (Table 6.2.).

Table 6.2.
Health and Safety evaluation

Sub-variables	Evaluation motive
V5a	existence of a formal safety policy
V5b, V5c, V5d	extent of the formal safety policy
V5e & V5f	existence / powers of internal H&S regime
V5g & V5h	company policy: H&S/first aid awareness
V5j & V5K	serious H&S contravention during the last 5 years

Information for V5a to V5d is available from contractor's internal safety policy document (HASWA 74, sec. 2(3)) Sub-variables V5e to V5k may be determined via a prequalification questionnaire.

6.1.6. V6: Litigation tendency

Here, quantitative evaluation is difficult due to intervening factors such as whether the contractor is plaintiff or defendant. It would also be wrong to prejudge the *validity* of any claim or defence by the contractor.

Association between litigation tendency and claims consciousness (V20) exists, in that disputed claims are often determined via legal action. V20, investigated later confirms the percentage of project cost overruns attributable to contractor claims. This when analysed with brief details of current / recent litigation is a means of evaluating *overall* claims / litigation tendency for the firm. 'Recent litigation' will encompass actions within the last three years -such a time scale being applied because the wheels of the judicial system turn very slowly.

Evaluation is performed on a scale of 1 to 10 guided by commentary attached thereto. Expressed as a decimal this will yield a variable score. Hence, the following need to be incorporated into the prequalification questionnaire;

a) details of current / recent (last 3 years) litigation which the contractor is a party;
b) result(s) of cases having received judgment (last 3 years).

6.1.7. V7: Ratio analysis of accounts

The use of financial ratios to analyse company accounts or predict corporate failure is not new (Pinches, et al, 1975; Abidali, 1990). Financial stability can be measured in part from examination of annual accounts, prepared under The Companies Act 1985 (Jones, 1976). The selection model compliments ratio analysis with other financial measures including turnover history, workload capacity and bank / credit references.

Ratio analysis offers both definitive statements and comparison measures. The definitive statement can be valued against 'norms' or critical limits. Comparison yields insight when the direction of trends is observed, often against typical ratio values for the given industrial sector. To facilitate trend analysis, results for the ratios utilised need to be derived for the last three trading years of the company under review (Abidali, 1990).

Ratio analysis offers three distinct forms of measurement;

a) *Profitability* -reflecting company performance. This is important because a firm generating profit almost never fails (Abidali, 1990);
b) *Liquidity* -a measure of financial stability. Liquidity ratios determine company ability to honour its current liabilities in an abnormal situation such as loss of trade or failure to receive monies from debtors etc.;
c) *Investor potential* -which evaluates the investment opportunity offered by the company to providers of investment / working capital.

The three ratios utilised within the model are those highlighted by Abidali, who found three particular measures to be an ultimate test of company solvency if their values decrease to the limits;

a) current ratio < 1.0;
b) net assets/current liabilities < 1.0;
c) pretax profit/interest < 2.0.

Current ratio -this is a broad indicator of company short term financial position (Holmes & Sugden, 1990) and is determined from the ratio: current assets/current liabilities. A ratio of more than 1.0 indicates a surplus of current assets over current liabilities. A ratio of 2 or more used to be considered prudent in order to maintain credit worthiness but in recent years a figure of about 1:1.5 has been generally acceptable and considered a more realistic limit for construction companies (Abidali;

Holmes & Sugden, 1990). Anything below this may be considered as worrying on the grounds of liquidity.

N.B. It is accepted that the *quick ratio*[4] (or *acid test* as it is often known) presents a more stringent analysis of liquidity because the numerator in the equation is smaller thereby making the critical limit more difficult to achieve. However, the quick ratio has not been utilised herein because Abidali found this more stringent approach insignificant, reflecting contractor's 'work in progress' as being easily convertible to cash in the construction industry.

Net assets/current liabilities -net assets is the sum of all fixed assets plus current assets minus current liabilities. Current liabilities are all sums repayable within 1 year eg., creditors, overdrafts, provisions and amounts such as corporation tax. A ratio score of less than 1.0 can place a company in danger of failure (ibid).

c) *Interest cover* -this is the amount of interest a company has to pay on its long *and* short term loans as a ratio of its pretax profits. Abidali confirmed that a ratio of less than 2.0 is a danger sign in terms of financial stability.

Trends for the above ratios are observed when scores are equal to, or above the critical limits identified. If ratio scores do not reach these limits then trend analysis is irrelevant. It is not proposed to penalise companies who's trends have remained stable -so long as they are stable *above* the critical limits.

Copies of the contractors' last three years trading accounts are required from which may be abstracted the required values for the ratios described. Each of the six measures (3 ratio scores, 3 trends) are equally weighted. Scoring is further elucidated in the prequalification analysis sheets (Appendix F).

[4] The formula is: Current assets minus stocks and work in progress/Current liabilities.

6.1.8. V8: Bank reference & V9: credit references

In the absence of a standard format in use by referees absolute quantification of bank and creditor references is an unrealistic ambition. These variables must rely on qualitative evaluation, based on information received (ie., references supplied with the prequalification questionnaire or consent for the practitioner to approach either source for such). Commentary attached to the scales (Appendix F) help make the evaluation as objective as possible.

6.1.8.1. V8: Bank

The firm should have been with it's bankers for a minimum of three years (refer *Age* earlier). If the contractor has recently made alternative banking arrangements, this might be construed as suspect in that the firm may not have enjoyed all the facilities (ie., confidence) it required of its former bankers?

6.1.8.2. V9: Trade creditors

Trade creditors should have at least three years trading history with the firm. A reference from a supplier who has been doing business with the contractor for only a short time is less credible; this supplier may be one who *is* being promptly paid because the particular materials / service, are crucial to the contractors business. Contractors procure materials from numerous sources therefore, identification of suppliers with a three year trading history should not be difficult. Current selection practice tends to observe two trade references and that number is proposed here. Each has a potential maximum significance of 0.5 on the resultant variable score.

6.1.9. V10: Turnover history

Turnover mirrors the extent of company trading for a given period, normally expressed annually. An increase in turnover represents growth which is a function of company survival since contraction is a threat (Barback, 1984). If turnover merely remains constant the company will still contract due to the effects of inflation. Hence turnover should increase by more than the rate of inflation if the business is progressing (Hutchinson & Dyer, 1987). A steady increase in turnover may be associated with positive management ie., increasing profitability, expanding company activities and maximising market opportunities.

Growth is a positive corporate phenomenon, but the growth scenario is not easy to evaluate. As Abidali warned, "Failing companies may tend to increase their turnover by overtrading" ie., contractors with cashflow or liquidity strangleholds may try to remedy their situation by tendering 'suicidally low' bids (see Merna & Smith, 1990) at a final attempt to generate cash in-flows. Albeit they increase turnover, unprofitable contracts inevitably contribute further to the firms demise.

Growth can also have an adverse effect on profitability, due to increased costs from attaining increased market share (fostering demand) and investment in innovation. Furthermore, there is potential for management to be less effective by spreading their effort over larger and / or more numerous activities (Barbeck, 1984). Finally, one must not overlook the fact that any increase in costs has to be financed typically, or at least partially from retained profits. Alternatively, loan capital may yield an unfavourable contribution to gearing (equity / debt capital). In summary, it is clear that a steady increase in turnover is a positive sign, save that it is evaluated with other factors and that such evaluation does not detect the unfavourable points highlighted.

Consistent growth is preferable but in view of the depressed construction sector of late, this may be unrealistic. It is proposed that stable turnover (no contraction) be satisfactory, but this will need review eg., in light of an upturn in demand.

The most recent three years trading are observed, mirroring Abidalis' trend analysis and, the period reviewed by the most comprehensive of current prequalification regimes. Three further checks may be carried out in parallel to determine;

a) *liquidity* -that it has not fallen below the critical limit of 1.0 as determined by the current ratio;
b) *profitability* -(ROCE)[5] that it has not declined on any previous year (Abidali found that the trend in profitability for solvent companies is always positive whilst for failing companies it declines sharply and becomes negative thereafter);
c) *gearing* -that it has not reached a critical limit of 50 percent or 1:1 as determined by the formula; equity & capital reserves/debt capital (Mott, 1992).

A company satisfying these criteria exhibits at minimum stable turnover or at best growth with no adverse effect and is therefore worthy of a maximum score. Where negative phenomenon exist the variable score is reduced accordingly (Appendix F). Evaluation data is readily available from company annual accounts (three years previous).

6.1.10. V11: Qualification of company owners

Involvement of company owners in the management process is dependent upon the nature and size of company. For example, a small private company Director, whilst being an owner is also a *manager* and hence deeply involved with the day-to-day running of the firm. Conversely, the owners of a public company are predominantly it's shareholders of whom the majority (dependent upon the share portfolio) have little to do with day-to-day management activities. Therefore, V11 needs to evaluate corporate *management*. To make this practical the *results* ie., performance, of management efforts (policy and strategy) will be measured as a means of

[5] Return on capital employed determined from the formula; profit before tax & interest payments/capital employed

identifying qualification and hence ability. *Qualified, experienced owners are more probable to make correct corporate decisions which will reflect in the companys' overall performance.* Such an approach to evaluate management was exploited by Diekmann (1979).

Scoring is achieved by observing company growth (turnover) along with the performance measures of time, cost and quality. Data is abstracted from; V10 (turnover history), V19 (time overruns), V20 (cost overruns) and V21 (quality performance).

6.1.11. V12: Qualification of key personnel

Previous research has confirmed that *site management* are the crucial key to a successful project outcome (Mustapha, 1990). "The site manager is responsible for the profitability of the contract by controlling all construction on site in accord with company and client requirements" (Harper, 1978). Furthermore, Lemarie (1982) stated that "all other resources rely on funding from the site management activity." Perhaps the most specific reference in identifying 'key personnel' emanates from Wakefield (1985) who confirmed; "The key man in the construction process is not the architect or the quantity surveyor, not even the contracts director, but the site manager". Obviously therefore, it is necessary to identify the quantity and quality of a contractors site management resource. "The quality of supervisory personnel assigned to a contract weighs heavily on the total efficiency of a contractors efforts" (Diekmann, 1979).

Four key areas have been identified by which to measure such investigation;

a) *Academic qualification* -site managers holding Degrees are better performing ones. Having pursued academic training they have advanced their communication and management techniques and, have greater familiarity with technological change. In short, they are better able to function within their working environment.

b) *Membership of a professional Institute* -effective projects are more probably supervised by a manager who is a member of a professional institute such as The Chartered Institute of Building or The Institute of Civil Engineers. Such bodies help sustain / further the knowledge of members, subsequently increasing their effectiveness.

c) *Age range* -optimum age has been identified as between 30 to 40 years. Mature managers are less likely to adapt to change or have academic qualifications. Conversely, younger managers have greater ambition for promotion and are more likely to have academic qualifications.

d) *Experience overseas* - correlation has been found to exist between managers who perform well and have had overseas experience (ibid).

Horgan (1987) further substantiated (a) & (b); "The percentage of staff who are graduates and members of recognised engineering institutions must be determined during prequalification".

Scoring is performed by observing the percentage of Contractor site management holding attributes (a) to (d). These percentages may be expressed as a decimal and multiplied by 0.25 to yield a potential maximum V score of 1.0.

6.1.12. V13: Key personnel -years with company

As discussed, the most favourable age of key personnel is between 30-40 years. Assuming a school leaving age of 18 then optimal experience within the industry will be between 12 and 22 years. A manager who has spent these years (trained with and come through the ranks as it were) with one particular company is further desirable, because this would also have facilitated interdepartmental training (Harris & McCaffer, 1987) hence greater familiarity of company organisational structure.

The percentage of a contractors site managers fulfilling the above criteria may be expressed as a decimal to yield a variable score.

6.1.13. V14: Formal training regime

Managers must necessarily co-ordinate resources to achieve both company and client objectives. *Qualification of key personnel* earlier highlighted that academic qualification was an essential ingredient of a successful manager. This has been emphasised elsewhere; "Technical skill usually follows some *formal education and training,* enabling the recipient to exercise expertise related to the procedures or methods of the organisation in an efficient manner. Many managers will have developed their technical skills through training" (Pilcher, 1992). Harris and McCaffer (1987) further expanded this theme, underlining the importance of broadening managers capabilities by way of internal experience; "Managers should be given experience in as many parts of the organisation as possible, it is essential to spend one or two years in a head office based department well supported with short courses in modern management techniques".

In conclusion, training improves manager ability to achieve company objectives which are fundamentally the objectives of the client (satisfactory completion of the project time, cost and quality).

Training best encompasses;

a) formal industry related education which should lead to a recognised qualification, the latter being a motivation goal for the trainee and a quantifiable measure of attainment;
b) broadening the competency of the manager by exercising an internal system of departmental work experience: estimating, planning, purchasing, production etc.

Scoring establishes whether these two attributes exist within the company, each worth a potential 0.5.

6.1.14. V15: Experience -type of projects completed

Here the underlying aim is to determine the extent of a contractor's *broad* prior experience; "Provided that other selection criteria are satisfied it would usually be safe to select a contractor who has the requisite experience of constructing buildings of a similar nature, scope and size" (Janssens, 1991).

To do so, firstly it is necessary to classify construction work into categories but, there are endless classifications if one considers the industrys' varied workload. The definitions used within "Housing and Construction Statistics" (H.M.S.O., 1992), might serve as a 'prompt list' (Table 6.3.).

Table 6.3.
Work type definitions

Generic definition	Work types
1. New Housing	public sector, private sector
2. New Work Public	railways, air transport, education, health, factories, oil, steel, warehouses, offices, shops, roads, harbours, waterways, water & sewerage
3. New Work Private Industrial	gas, electricity, coal mining, factories, warehouses
4. New Work Private Commercial	offices, shops, entertainment, garages, schools & colleges, agriculture
5. Repair and Maintenance	housing, public section 2 above, private sections 3, 4, above.

It is proposed that the practitioner / client selects four work types, firstly to simplify scoring (ie., each worth 0.25) and secondly because four is adequate to perform the required *broad* assessment. Obviously these four prerequisites must be relevant to the proposed project. For example, a client with a multi storey office and extensive car parking facilities project, may require experience of;

a) demolition within confined spaces;
b) multi storey office construction (framed structures);
c) multi storey concrete cladding systems;
d) tarmaccadam / brick paviour pavement construction.

The practitioner should therefore request details of projects completed within the last two years, (as to be considered recent experience) confirming satisfactory execution of each work type. Client details are also often requested for follow up investigation where deemed necessary.

6.1.15. V16: Experience -size of projects completed

This investigation measures contractor potential in terms of;

a) ability to commit adequate resources to a large project ie., does the proposed project represent something in excess of what the contractor has previously experienced both in terms of financial / organisational resources? A £multi-million prestige development would not be ideally undertaken by a firm used to minor works -even where the contractor has adequate capacity. In this instance it is the *size* of the project which is not compatible;
b) ability to 'scale down' operations by a contractor more used to major works but who may be tendering in this instance for a small contract. "The project should not be so small in relation to a contractors *normal* type of work, that the firm would be unlikely to submit a competitive tender" (Janssens 1991).

Contractor / project size compatibility is necessary, as evidenced by observing larger companies departmentalising operations to cater for comparable sized projects eg., *Major works division, Minor works division, Refurbishment works division,* and so on. This is further confirmed when one considers the public sector who match contractor to project size via contract value (£) bands, when compiling select lists.

Universal classification (£) is difficult to achieve because what may be regarded as a large project for one client may be medium or small as perceived by another. For example, liaison with one particular public sector client has identified their size bands as; small projects ≤ £25K, medium size projects > £25K ≤ £100K, large projects >£100 ≤ £250K (rarely do they assign projects in excess of £250K).

However the client is small in relative terms and a larger authority would initiate a shift upwards in setting such size / value categories.

Therefore, two modes of evaluation need be employed;

a) has the contractor executed a similar sized project within the last three years to that proposed?
b) is the proposed project of a size *most often* undertaken by the contractor?

Therefore, the prequalification questionnaire needs determine the largest value project (£) undertaken by the contractor, within the last three years (as a means of making a like-for-like comparison when the time value of money is considered). So (a) above is relatively straightforward -the firm either has, or has not, executed a similar sized project. Part (b) requires that the contractor indicates the contract value ranges most often undertaken by the firm ie., from £X to £Y.

As an example say a clients in-house cost estimate for a proposed project is £950K (obviously the client will not disclose this). If the contractor completed a project value £1.5M one year ago and normally undertakes work in the range £750K to £1.5M, then both criteria are fulfilled and a maximum score may be awarded (ie., worth 0.5 each).

6.1.16. V17: National or local experience

Has a contractor been confined to working within a particular geographic region or has that experience been national? Horgan (1987) contended that *geographic areas of operation* should be determined during the prequalification exercise. Three things are relative;

a) a firm's structure ('national or local' company) and hence;
b) the extent of catchment, which affects;
c) the firms 'mobility' potential.

A national company should have maximum geographic experience but this might have been achieved achieved via a network of regional offices. If regional offices are considered in isolation they would probably be construed as only having had local experience. Nonetheless, a national company does have maximum catchment and therefore greater ability to tackle certain types of project or contract, such as a continuity contract where works may be geographically spread, or a term contract (eg., maintenance) for a client with national properties. A national company will also have a greater range of in-house skills and resources established to cope with the demands of serving a larger catchment.

Furthermore, within each region, a contractor will have established trading links with local suppliers and labour. Having to establish these in a 'new' area is often restrictive to the firm in that a 'track record' for the company is not in existence. (Previous geographic experience *within the area of the proposed project* is examined under P2 analysis).

Scoring is achieved by dividing the mainland into ten geographical regions and identifying whether or not a contractor has executed a contract of a minimum two month duration within each during the last two years.

Delineation is based upon Regional Water Authority areas with slight modification; a) introducing the whole of Scotland as one region in itself due to it's lower population density, b) combining the two smallest water authority regions (Thames / Southern) into one and c) assigning counties which lie between two regions into only one. Zones thus created do not correlate exactly with the water authority regions but this approach does conveniently divide the country into ten distinct areas (Table 6.4.).

Table 6.4.
Geographic regions

Region	Counties
Scottish Region	
Northumbrian Region	Northumberland, Tyne and Wear, Durham, Cleveland, North Yorkshire.
North West Region	Cumbria, Lancashire, Greater Manchester, Merseyside, Cheshire.
Yorkshire Region	West Yorkshire, Humberside, South Yorkshire, Derbyshire.
Welsh region	Gwynedd, Clwyd, Dyfed, Powys, West Glamorgan, Mid Glamorgan, South Glamorgan, Gwent.
Severn Trent region	Shropshire, Staffordshire, Nottinghamshire, Leicestershire, West Midlands, Hereford & Worcestershire, Warwickshire.
Anglian Region	Lincolnshire, Cambridgeshire, Norfolk, Northamptonshire, Suffolk, Bedfordshire, Essex.
South West region	Cornwall, Devon.
Wessex Region	Gloucestershire, Avon, Wiltshire, Somerset, Dorset.
Thames & Southern region	Oxfordshire, Buckinghamshire, Herts, Greater London, Berkshire, Kent, Surrey, Hampshire, West Sussex, East Sussex.

The two year qualification identifies catchment within a set time scale ie., if a company's geographic experience were considered throughout it's lifetime, then it would certainly exhibit a larger catchment, but this would not be representative. A two month contract qualification ensures the project was of ample size to be considered relevant experience. However, the practitioner may decide to vary the latter -the longer the contract period the greater experience accrued. For each region within which a contractor has worked as qualified above, a score of 0.1 is awarded to a maximum V score of 1.0.

6.1.17. V18: Failure to have completed a contract

Ideally, a contractor carries out contract obligations to the satisfaction of the client and, the client reciprocates by payment. The discharging of a contract in such a way is called termination by performance ie., each party performs their duties to the other under it.

However, a surprising number of construction contracts end prematurely for one reason or another and large sums of money can depend upon the validity or otherwise of the determination (Smith & Sims, 1985). Determination may take various forms, prime examples of which are;

a) *by agreement* -where both parties agree that the contract should come to an end for whatever reason, whether the contract obligations have been completed or not;

b) *by frustration* -referred to legally as 'supervening impossibility of performance'. This means that events beyond the control of both parties render the contract something completely different from what was originally contemplated;

c) *by repudiation* -this may occur if;

   i) conduct by either party indicates that the repudiating party will not perform the contract or;

ii) a contracting partys' performance is so grossly defective it goes straight to the root of the contract.

Where the innocent party 'accepts' the repudiation the contract is terminated and the innocent party is excused from further performance. Wrongful repudiation does not itself discharge the contract, termination only occurs if the other party accepts the repudiation. Where it is not accepted the innocent party may sue for *specific performance* by the other party and / or damages for the breach.

The above is only an outline -construction contract law is a very complex area. However, the salient point is that where a contractor has failed to complete a contract (achieve termination by performance) then the reason must be confirmed. However, non-completion is not always a negative phenomenon, determination by agreement for instance, does not necessarily discredit the contractor.

A maximum score is awarded to a contractor who has never failed to complete a contract. Where a contractor has not achieved termination by performance, then the reason will establish whether any fault lies with the firm. Where no fault is found then a full score is also deserving.

Non-performance by the contractor is viewed with concern by clients This, considered with contractor company failure is possibly the worst possible out-turn for the client in terms of project satisfaction. Where no valid reason for non completion exists then a contractor shall receive a zero score.

Details of all contracts (if any) of which the contractor has failed to complete and reason/s for non-completion must therefore be established via the prequalification questionnaire.

6.1.18. V19 to V21 -foreword

The following three variables (V19 to 21) need be considered collectively because they require the practitioner to communicate with previous clients. By grouping these P1 variables together then the information for evaluation may be obtained in a single enquiry to client referees supplied in the prequalification questionnaire.

6.1.19. V19: Time overruns

To what extent are time overruns due to the contractors' failing? A firm should not be penalised where the time overrun is due to circumstances beyond the contractors control such as work additions / variations. Hence, enquiry made to the referee needs to ask; "Was your contract finished by the completion date (allow for extensions of time where granted). If not, what were the reasons for the time overrun?". Where overruns did not occur then the contractor deserves a maximum score, but the contractor is penalised where overruns did occur (Appendix F).

6.1.20. V20: Overruns cost

A contractor loosing money will invariably seek ways to redress the situation hence, claims consciousness must be established (Janssens, 1991).

Under the general provisions of an employer / contractor construction contract the contractors' benefit is the contract sum (£). This is paid by the employer albeit 'in instalments' in consideration of the contractor completing his obligations to the contract. Mechanisms by which this contract sum may enlarge ie., overrun original contract sum is by one or all of the following increases in cost;

a) price fluctuations (where a fluctuations clause pertains);
b) variations in the works (additions or higher specification);
c) monetary claims by the contractor.

In the context of this research (c) requires investigation.

Within construction the word claim is used for any application by the contractor for payment, other than under the ordinary contract provisions (Powell-Smith & Sims, 1989). The four types of claim are;

a) *Contractual* -arising out of express provisions of the contract ie., direct loss and / or expense (JCT standard forms);
b) *Common law* -damages for breach of contract at common law and / or legally enforceable claims for breach of some other aspect of law eg., breach of copyright;
c) *Quantum meruit* -a remedy for where work has been carried out but no price was agreed or where the original contract was replaced by a new one, and payment is claimed for work done under the latter;
d) *Ex gratia* -a claim to which the employer has no obligation but may honour if some other benefit will accrue from such payment.

Scoring is done by analysing the client references to determine whether cost overruns occurred and if so, what percentage of such overruns were attributable to contractor claims. Appendix F details the scoring mechanism.

6.1.21. V21: Actual quality achieved

Quality Control Policy (V4 earlier) investigated to what extent a QA system existed within a contractor organisation. However, proof of the pudding is in the eating so this variable is scored as a function of client (quality) satisfaction.

Enquiry to the referee should ask; "With reference to contract (name) please indicate your level of satisfaction in terms of *quality of the finished product*. (Copy of scale 1-10 as per appendix F to be supplied).

6.2. EVALUATING P2 VARIABLES

6.2.1. V22: Experience geographically

The prequalification variable *National or local experience* determined the overall catchment of the contractor. *This* P2 variable determines actual experience in the specific area of the proposed project. As earlier confirmed, familiarity of an area brings with it business relationships ie., local labour and suppliers. In the alternative, such relationships have to be established over time and often need to be based on an element of trust and 'track record'. As the C.I.O.B. pointed out; "A client should ensure that the contractors experience covers the type of construction required and that he is familiar with the area in which the project is located" (I.O.B., 1979). Furthermore; "It is important that the contractor knows the area well. To give the firm an additional problem of working in an unknown territory could well give rise to unmanageable difficulties" (Janssens, 1991).

A maximum distance between the proposed project and the nearest previous / current contract executed by the contractor firstly needs to be established -this is proposed as 25 miles radius from the proposed project location. Previous contract execution within this area may be regarded as experience within the area of the project. Twenty five miles is chosen because anything less could be construed as too strict a prerequisite whilst a larger radius would encompass too large an area - work carried out on the periphery of which would have less substance in terms of being in the locality of the proposed project.

In order to attain a maximum variable score the contractor needs to confirm execution of a contract within the defined area;

a) within the last three years (a longer time may mean that business relationships and / or benefits of experience gained may have eroded);

b) of a minimum 6 months duration (a reasonable time during which the contractor should have established trading links and an understanding of local labour/suppliers).

6.2.2. V23: Experience of a similar construction

During prequalification V15 investigated a contractor's broad work experience. This variable performs a similar duty and indeed utilises a similar method of evaluation. However, the work types are much more specific. To be effective the work types chosen must be peculiar and somewhat crucial to the effective execution of the proposed contract, helping to identify those contractors with most potential for *this project.*

Selection of work types must be at the discretion of the owner. This is because the owners understanding of the construction process combined with familiarity of *the proposed project* will best be able to identify such crucial work elements. An input may be encouraged from the client because client perception of an ideal outcome (particularly in terms of quality) must be recognised in order to achieve a satisfactory project conclusion.

Many elements of construction are carried out by sub-contractors. It could be argued therefore that the main contractor does not achieve 'hands on' experience of many work types. Nonetheless, the main contractor will gain experience of managing / controlling those tasks and this is to be considered adequate. Considering the structure of this industry it would be unrealistic to expect that a main contractor has actually physically performed *every* aspect of construction.

The practitioner may choose to observe the work definitions cited in The Standard Method of Measurement (7th Edition 1989) as a basis for choosing ten specific work types. Ten are chosen because this provides ample scope for the practitioner to discriminate whilst also simplifying scoring (each element worth 0.1). SMM definitions are suggested because they are universally recognisable throughout the building sector and such definitions are also mirrored in the Coordinated Project Information (1987) editions.

For civil engineering contracts the practitioner may wish to consult the Civil Engineering Standard Method of Measurement (Telford, 1991).

Table 6.5.
Specific work types

SMM classification	Work type areas
C	demolition / alteration / renovation
D	groundwork
E	insitu concrete / large precast concrete
F	masonry
G	structural / carcassing metal / timber
H	cladding / covering
J	waterproofing
K	linings / sheathing / dry partitioning
L	windows / doors / stairs
M	surface finishes
N	furniture / equipment
P	building fabric sundries
Q	paving / planting / fencing / site furniture
R	disposal systems
S	piped supply systems
T	mechanical heating / cooling / refrigeration systems
U	ventilation / air conditioning systems
V	electrical supply / power / lighting systems
W	communications / security / control systems
X	transport systems
Y	mechanical and electrical services

Identification C to Y corresponds with SMM7. Items A & B are omitted -the former deals with preliminaries, the latter with complete buildings. SMM 7 further decomposes each head allowing most specific definition to be achieved.

Scoring is achieved by determining whether the contractor can provide brief details of a contract executed within the last 2 years, showing experience in each of the ten elements chosen. The two year qualification ensures that experience gained is recent, not least because of how fast technology can change within the construction industry. However, the practitioner is at liberty to adjust this period as seen fit.

6.2.3. V24: Plant policy

The scale of many construction projects combined with shorter construction times makes the extensive use of plant essential in the construction process (Harris & McCaffer, 1991). Ownership of plant and equipment is not a fundamental requirement to a construction company because a vast amount is available for hire as an alternative. However, ownership does facilitate convenience and prestige. Contractors may fulfil their plant requirements in one of three ways;

a) *Owning all equipment* -this means that plant is available to the contractor at all times although day-today requirements and size of fleet determine specific availability. The main disadvantage is that large sums of capital are tied up in ownership, which subsequently requires high levels of utilisation to maintain such investment as profitable. Ownership policy also proves a liability in times of recession. Contractors may be forced to submit suicidally low bids (Merna & Smith, 1990) for work as a means of attempting to maintain utilisation levels. This of course is non-conducive to profitability and hence financial stability.

b) *Hiring all equipment* -here the contractor avoids large capital investment sums and costs-in-use: consumables and maintenance. However, the firm is at the mercy of the hire sector in terms of; i). availability of specific items of plant particularly when demand is high and ii). the contractor may be prone to unforeseen or sudden price increases in hire charge rates. The latter (ii) is dependent upon prevalent market forces. Substantial adverse cost variance may exist between the amount a contractor allowed in compilation of tender and the actual costs incurred when the plant is hired. In such circumstances and where hire requirements form a large part of the contract then potential for financial loss on the project is accentuated.

c) *Combination of own and hire* -this policy reflects a mix of both the former options and as such, apportions the advantages and disadvantages associated with each respectively. From this viewpoint it is the best all round method of plant procurement.

Hence, part of plant policy evaluation must be to ascertain which acquisition policy the contractor pursues. The combination of own and hire is most desirable because it negates the 'major' elements of risk associated with an 'all own' or 'all hire' approach, but, allows the contractor to fulfil the plant requirements of the contract.

Finally, evaluation must incorporate an assessment of the contractors perception of plant requirements for the proposed contract, misconception here could lead to major problems once the project is under way. Indeed, correct identification of plant requirements for the project is essential to help arrive at a realistic tender price (Humphries, 1994).

In summary, the contractors perception of major plant requirements for proposed project and confirmation of plant acquisition policy are required - see Appendix H for scoring details.

6.2.4. V25: Key persons available for project

Prequalification (V12) identified the overall management resource at the contractors disposal. It may be that such is in abundance, but there is always the possibility that these managers are unavailable eg., committed to alternative projects. Furthermore, the contractors perception of managerial requirement may be underestimated.

Therefore, V15 aims to establish precisely what site management structure the contractor intends for the proposed project (measured in terms of quantity because quality is measured under V26).

Firstly, the practitioner needs to make an assessment of the management structure required to effectively execute the project. Regarding this point three things need mention;

a) notwithstanding qualitative assessment an experienced construction professional can make a reasoned judgment;
b) the practitioner should be familiar with the construction process; and
c) factors influencing assessment of the required management structure will predominantly include; complexity, nature and size of project.

For scoring purposes the structure needs to be categorised in terms of *first line* and *senior* managers. Designation of site management will vary in accordance with the size of company (Mustapha, 1990) and this must be considered when evaluating requirements (Table 6.2.).

Table 6.6.
Designation of site management in relation to company size

Small Co'	Medium Co'	Large Co'
Contracts Director	Contracts Director	Regional Contracts Director
Contracts Manager	Contracts Manager	Regional Contracts Manager
Contract Supervisor	Project Manager	Project Manager
Site Manager	Site Manager	Site Manager
Site Foreman	Section Manager	Section Manager
	Site Foreman	Site Foreman

Adapted from Mustapha 1990.

Once a suitable management structure is agreed it may be compared with what the contractor intends. This is best shown by example;

Practitioners assessment of the required management structure is:-

i) *Senior managers* -Visiting Contracts Manager, Site Manager, 2 Section Managers

ii) *First line* -6 Foremen.

Contractors proposed management structure is:-

i) *Senior managers* -as above

ii) *First line* -3 Foremen.

Evaluation may then compare the proposed against desired eg.,

Senior managers	= 4 proposed/4 desired	= 100%	x 0.5 = 0.50
First line managers	= 3 proposed/6 desired	= 50%	x 0.5 = 0.25
		Total V25 score =	0.75

Hence, details of intended contractor management structure for the project must be determined from the tenderer evaluation questionnaire.

6.2.5. V26: Qualification of key persons available

The previous variable investigated the *quantity* of site management resource. This variable investigates the *qualification* of that commitment. The necessary attributes of effective site management were identified earlier as;

a) academic qualification to degree level;

b) membership of a professional institute;

c) age range 30 - 40 years;

d) overseas construction experience.

These performance measures are to be utilised here also. *Key persons available* refers to the permanent on-site management structure outlined by the contractor in V25 above, as being committed to the proposed project. Respective percentages of this proposed structure holding each of the four the attributes above, may be expressed as decimals and multiplied by 0.25 to yield a potential maximum score of 1.0. Appendix H elucidates this mechanism.

6.2.6. V27: Current workload

During P1 analysis, maximum financial capacity (MFC) of the contractor was estimated (maximum value of work in progress that the company could be committed to without payment). This figure was used for approximate comparison with Maximum Financial Outlay (MFO) for the proposed project. V27 conducts a similar *but more detailed* analysis, by calculating MFC, then allowing for all current / forthcoming commitments throughout the duration of the proposed project thus evaluating the possibility of overtrading. "The employer should satisfy that the contractor will be able to call upon the requisite resources for the construction of the works when needed" (Janssens, 1991).

Workload capacity is determined from the formula; *Gross* MFC[6] minus committed resources[7]. This is best shown by example;

a) assume proposed project estimated value is £1.4M, estimated contract period is 14 months;
b) assume contractors' current workload is;

    Contract (a): value £900,000 contract period 12 months
    Contract (b): value £800,000 contract period 10 months
    Contract (c): value £450,000 contract period 6 months*

[6] No modifying coefficient applied - under P1 the modifying coefficient 'estimated' that half the contractors capability would be committed to other contracts. Here that commitment is actually calculated.

[7] Commitment to current workload plus anticipated contracts to be commenced during proposed contract period.

**To be commenced during period of proposed contract*

We may now calculate the contractors' maximum financial outlay (MFO). A simple linear relationship between expenditure / time is assumed and, that maximum commitment represents 2 months work because of interim payment delay. Hence;

contract (a) 2(900K/12)	= 150,000
contract (b) 2(800K/10)	= 160,000
contract (c) 2(450K/6)	= <u>150,000</u>
MFO =	£460,000

To this must be added the contractors' commitment to the proposed contract (assume tender was successful) based on the in-house cost / duration estimates above ie: 2(1.4M/14) = £200,000. Therefore, maximum possible gross financial outlay at any time during proposed contract period is: (£460K + £200K) =£660,000.

So, if the contractors gross MFC is > £660,000 then the firms workload capacity is ample and awarded a maximum score. Zero is awarded where the converse is true. In summary, maximum financial outlay may be determined via the formula;

$$\sum_{i=1}^{n} 2(V_i / D_i)$$

where; V = contract values (£), D = contract durations (months) and n=all contracts being undertaken (including that being tendered for) or to be undertaken during proposed project period.

Gross MFC (not adjusted via any modifying coefficient) may be observed from V1 under P1 analysis.

6.2.7. V28: Prior relationship

Previous professional relationships are regarded as important by both contractors and clients, indeed research has confirmed that client related factors ranked highest when contractors were deciding which jobs to tender for (Odusote, 1990). Furthermore, where contractor's resources are committed firms would rather reflect a non-desire to win the award in a high tender price, rather than refusing to tender, for fear of adverse affect on client / contractor relationship (Peter, 1981).

From the clients' standpoint a good working relationship throughout the contract is essential. This aids communication reducing the risk of misunderstandings yielding greater probability of a successful project outcome. However, as with other criteria (cf. age or financial standing) successful *prior* relationships cannot automatically mean a successful future one.

If a contractor has not previously had a working relationship with the client then that firm scores zero. This may seem unfair on some contractors but if a previous relationship doesn't exist for certain contractors then they cannot be scored for it.

Those contractors who *have* had a previous working relationship with a client are scored upon a scale which ranges from 0 to 1.0. It is quite possible therefore that contractors of previous professional relationship with the client may also be prone to zero that is, the relationship may have been a poor one!

Time, cost (overruns), and quality (achieved) throughout the previous relationship is not evaluated -this is done elsewhere. The clients' score should reflect general willingness by the firm to achieve client satisfaction.

6.2.8. V29: Home office location in relation to project

Location of the contractors' head / regional office is important in terms of ability of key personnel to remain in close contact with the project. Speed of decision making and communication between site / office management, the client and, consultants, may be hindered where the contractor is based further away from the project. Furthermore, being within the project area the firm will have a greater understanding of;

a) local labour -employees are within easy travelling distance of the project and working relationships with local subcontractors should be established;
b) local suppliers -trade accounts will be in existence thus procurement of materials, components, plant services etc. will be relatively straightforward. This is a distinct advantage when viewed in comparison to contractors from 'outside' the area.

A maximum V score is awarded where a contractors office is within a 25 mile radius of the proposed project.

6.2.9. V30: Weather

The ramifications of this variable are fixed ie., in the majority of instances the contract start date and period is predetermined and applicable to all tenderers. Subsequently, the variable is not discriminatory.

An exception exists where contractors are invited to state their earliest start date / contract period. However, in these instances the the shortest contract period is most likely to take precedence over the weather encountered en route. For these reasons the variable is not considered further in terms of evaluation.

However, Humphries (1994) confirmed: "Timing of contract is important having regard for inclement weather and holiday periods".

6.2.10. V31: Form of contract

Here again, is an item that is generally predetermined by the client or consultants and is not therefore discriminatory. Where qualified submissions do allow alternative suggestion regarding form of contract, then the practitioner will have to make a subjective assessment of each in the decision process. Incidentally, this variable also ranked lowest of all five considered under the factor *project specific*, in the survey of construction owners earlier.

6.3. SUMMARY

Based on a thorough investigation, the methods of converting natural units (£, years, number of, yes/no, etc.,) to commensurate values (0.0 to 1.0.) have been established for each attribute.

This facilitates the integration of such commensurate values, for a given contractors attributes, into the model, enabling a numeric aggregate measure to be computed (Holt et al., 1994A; 1994B).

Identification of input data for evaluation was therefore able to mould the prequalification and tenderer evaluation questionnaires. These are fully explained in the worked example of the model which now follows in Chapter 7.

CHAPTER 7

A WORKED EXAMPLE OF THE SELECTION MODEL

7.0. INTRODUCTION

In order to clarify application of the developed selection model to real life selection exercises later (Chapter 8), this chapter presents a fully worked example of the technique. To comprehensively elucidate the mechanics of the technique, it is applied to an hypothetical but realistic selection scenario concerning the award of a small industrial project. Specifically, the fortunes of one particular contractor (contractor number 1 designated Cr_1) are followed from prequalification, through tender evaluation, to final selection. The exercise also highlights the influence of utility on the ultimate outcome and, how the time value of capital (tender sum) may be considered during evaluation.

In short, the Chapter confirms how a contractor who may not have submitted the lowest bid, may still be the best all-round prospect for the contract when a broad cocktail of performance criteria are considered, in tandem with tender figure.

7.1. DATA COLLECTION AND PROCESSING

Initially, it is necessary to understand the documentation and methodology developed to practically apply the model. For cross referencing purposes, contractors 1, 2, .., n are prefixed by Cr ie.,Cr_1, Cr_2, .., Cr_n.

7.1.1. Data collection

The pro-forma documentation introduced in the previous Chapter dealt with P1 and

P2 analysis (refer appendices F to I). In doing so this also identified the data required of contractors to conduct such evaluation. To this must be added the input data from clients (utility values etc.). We may therefore list all data required as emanating from three sources *viz*;

a) prequalification data -required from all contractors *desirous* to tender;
b) secondary evaluation data -from those contractors subsequently *invited* to tender;
c) client data -for inclusion in P2 analysis.

These may each be investigated in turn;

7.1.1.1. Prequalification data

Appendix J exhibits the prequalification questionnaire designed to collect P1 data from contractors desirous to tender. Questions 1 to 16 request all necessary information required for P1 analysis. Before presentation to contractors the questionnaire requires the selection practitioner to indicate under question 12, the four work types that will discriminate in terms of *past experience -type of projects completed.* This will facilitate evaluation of V15 (refer 6.1.14).

7.1.1.2. Secondary evaluation data

Appendix K exhibits the P2 questionnaire used to collate data from only those contractors invited to tender. Questions 1 to 6 request all necessary *contractor* information required for P2 analysis. Before presentation to contractors the practitioner is required to annotate thereon;

a) for question 2, a maximum of ten specific work types that will discriminate in terms of *experience - similar construction*. This facilitates evaluation of V23 (refer 6.2.2.);
b) for question 5, the period of the proposed project in months. This will be used in evaluation of V27: *current workload* (refer 6.2.6).

7.1.1.3. Client data

Appendix L exhibits the questionnaire used to collate that information which forms an input from the client during P2 analysis. Specifically it provides answers for;

a) questions 1 and 2 for V25: *key persons available for the project;*
b) question 3 for V28: *prior relationship;*
c) question 4 for V24: *plant acquisition policy;*
d) questions 5.1 to 5.8: to determine utility values for each P2 variable (refer 5.3.2.3.).

7.1.2. Data processing

Having collected all necessary input data evaluation may begin. This can be identified as a two stage process;

a) longhand analysis;
b) computer analysis.

Each is now explained in some detail.

7.1.2.1. Longhand analysis

This involves the abstracting of contractor information from P1, P2 and client questionnaires (appendices J to L above), along with information from supporting documents such as contractor financial accounts, health & safety policy statement, references etc. This input data is analysed via the processes detailed in the previous Chapter and subsequently converted into commensurable values for inclusion in the model, on the P1 analysis sheets (refer appendix F) and P2 analysis sheets (refer appendix H).

7.1.2.2. Computer analysis

Appendices G and I, previously exhibited the P1 and P2 summary analysis sheets respectively. These summary analysis sheets were originally developed for computation of P1 and P2 scores. However, in view of the laborious and time consuming nature of this task, a computer spreadsheet was developed for this purpose. Appendix M exhibits blank computer analysis sheets.

Input of contractor *V* scores into the relevant spreadsheet cells enables automatic production of;

a) rationalised scores for each variable;
b) factor scores for each factor;
c) a P1 score;
d) a P2 score.

Finally, once tender sums are known then the input of *lowest bid submitted for project* (£) and *this contractors bid for project* (£) produces firstly a bid score and subsequently a final P3 score.

Within the example of P1 and P2 computation that follows, the manner of inputting variable scores and respective outputs of the spreadsheet, are discussed in further detail.

7.2. THE SELECTION SCENARIO

For the purposes of this example a small industrial development with a gross floor area of approx. 1650 M^2 is assumed. The client estimates that the contract value will be in the region of £484,000 made up as follows;

		£ '000
Building cost including light, power and heating services but ignoring any effect of VAT / loose or special equipment @ £267/M^2 *		440,000
Add 10% for external works/sundry items		44,000
	Estimated cost:	**£484,000**

* *mean value from Spons (1993).*

It is important to appreciate that in practice a more comprehensive cost analysis is preferred, because a realistic estimate by which tender submissions may be compared is a vital component in the quality of selection decision made (Hawwash, 1991A).

Having outlined the project, we may now assume that six contractors will be invited to tender (contractors Cr_1, Cr_2, ..., Cr_6). We will firstly follow the specific fortunes of contractor number 1 ie., Cr_1 throughout, followed by investigation of how Cr_1 compares against all other tenderers during P2 and P3 analysis. Note that for cross-referencing purposes, the discriminating criteria maintain their 'V' prefix explained in Chapter 6 (refer 6.0.1.).

7.3. PREQUALIFYING THE CONTRACTOR -P1 ANALYSIS

7.3.1. Factor: Contractor organisation

7.3.1.1. V1: Size

Approximate contractor maximum financial outlay (MFO) = 2(CS/CP) where CS = contract sum (£) and CP = contract period (months). Therefore, 2(£484K/10 months) so MFO = £96.8K.

Maximum financial capacity (MFC) = M((CA-CL) +[0.5(NCA)] - NCL) where, M = modifying coefficient (0.5), CA = current assets, CL = current liabilities, NCA = non current assets and NCL = non current liabilities. From Cr_1's balance sheet (latest audited accounts), the following figures have been abstracted: fixed assets (tangible) £800,000; fixed assets (intangible) £20,000; current assets £300,000; liabilities due 1 year £250,000 and non-current liabilities £250,000. Therefore; 0.5 ([300-250] + (0.5[820]) - 250) so MFC = £105K.

Hence, utilising the 'standard' modifying coefficient of 0.5 (refer 6.1.1.) then Cr_1 has an MFC > MFO ie., £105K > £96.8K therefore V1 score = 1.0.

7.3.1.2. V2: Age

Cr_1 has traded within the construction sector under the same company name for at least three years, therefore V2 score = 1.0.

7.3.1.3. V3: Image

Cr_1 exhibits the following company membership: The C.I.O.B. Chartered Company Scheme (C.I.O.B., 1992) and the Federation of Master Builders (Henderson & Henderson, 1992). Hence, (2 x 0.5) = V3 score = 1.0.

7.3.1.4. V4: Quality control policy

Having attained full B.S. 5750 accreditation the firm achieves maximum V4 score of 1.0.

7.3.1.5. V5: Health and safety policy

Investigation of the ten H&S attributes is performed - Cr_1 fails on V5c: (not stating within safety policy that health and safety are given highest priority), V5e: (not having a permanent health and safety department) and V5f: (not having company health and safety representatives). Each sub-variable scores 0.1 so V5 = 0.7.

7.3.1.6. V6: Litigation tendency

The comments adjacent points 1, 5 and 10 on the evaluation scale (refer Appendix F -V6) aid scoring. Variable 20 (below) shows that Cr_1 is cited by a previous client referee as being 40 percent responsible for cost / claims overrun. However, the contractor has no current legal actions. This situation is slightly better than that described by the comment relative to a rating of 5, so a rating of 7 is awarded. Hence, V6 score = 0.7.

7.3.2. **Factor: financial stability**

7.3.2.1. V7: Ratio analysis of accounts

Cr_1 scores on four of the six measures V7a to V7f. The two failed on are;

a) V7d: net assets to current liabilities trend analysis shows a decline (yr 1= 2.0, yr 2 = 1.9, current year = 1.0);
b) V7f: interest cover trend analysis also shows decline; (yr 1 = 6, yr 2 = 4, current year = 3).

Inspection of the firms' profit and loss account confirms the decline in pretax profit highlighted under V7f. Variable score (4 x 0.167) = 0.67.

7.3.2.2. V8: Bank reference

Cr_1 has the requisite three year track record with it's bankers, who have furnished a 'good' reference, this being awarded a rating of 8, so V8 score = 0.8.

7.3.2.3. V9: Credit references

Trade creditor references supplied are awarded the following ratings: referee number 1 rating 9.0, referee number 2 rating 8.0. Therefore, [(9 + 8)/20] = 0.85.

7.3.2.4. V10: Turnover history

Analysis of the firms debt to equity capital (gearing), reveals a ratio of 2:1. Therefore, gearing has reached the critical limit of 50 percent during the period, this corresponding.with the increase in borrowing detected under V7 earlier. The three remaining measures V10a to V10c are positive so (3 x 0.25) = V10 = 0.75.

7.3.3. Factor: Management resource

7.3.3.1. V11: Qualification of company owners

The four performance measures utilised are;

a) Turnover (from V10 score):	0.75
b) Time performance (from V19 score):	0.75
c) Cost performance (from V20 score):	0.80
d) Quality performance (from V21 score):	0.85
	3.15

Therefore, 3.15/4 = variable score so V11 = 0.785.

7.3.3.2. V12: Qualification of key personnel

From the percentages indicated in the questionnaire analysis takes the form;

degree standard	80%	(0.8 x 0.25) = 0.20
professional institute	80%	(0.8 x 0.25) = 0.20
optimum age	60%	(0.4 x 0.25) = 0.15
overseas experience	40%	(0.4 x 0.25) = 0.10
		Therefore V12 = 0.65

7.3.3.3. V13: Key personnel years with company

Due to the contractors positive attributes with regard to training (see V14 below), 80 percent of management fulfil the V13 criterion of having been with the company since beginning employment and remaining in the firms employ for between 12 and 22 years. Hence 80% equates to V13 = 0.8.

7.3.3.4. V14: Formal training regime

Cr_1 pursues both of the positive training attributes applicable;

a) all managers are encouraged to attend part time day release study for higher or professional award;

b) interdepartmental training is compulsory to all company staff.

V14 (2 x 0.5) = 1.0.

7.3.4. Factor: Past experience

7.3.4.1. V15: Experience: type of projects completed

Cr_1 has indicated the necessary experience in three of the four work types chosen by the practitioner. Therefore, (3 x 0.25) so V15 = 0.75.

7.3.4.2. V16: Experience: size of projects completed

Cr_1 indicated the size of project most often undertaken as being circa £500K. The largest contract executed by the firm within the last three years was valued at

£800K. Therefore, the contractor *has* executed a contract of similar size to the proposed project within the last three years and, the project is of a size *normally* undertaken. Both items being worth 0.5 V16 score = 1.0.

7.3.4.3. V17: National or local experience

Cr_1 has provided details of a contract minimum duration two months and executed within the last two years, within six of the ten regions on the P1 questionnaire. So (6 x 0.1) V17 = 0.6.

7.3.5. Factor: Past performance

7.3.5.1. V18: Failure to have completed a contract

Having never failed to complete a contract no further analysis is necessary and a maximum score is achieved by the Cr_1. V18 = 1.0.

The following variables (V19, V20 & V21) are evaluated via information provided from two of the contractors previous clients (ie., from those supplied under V15).

7.3.5.2. V19: Time overruns

The first referees' contract was completed on time (score = 0.5). The second referee indicated a contract overrun but this was only partly due to the contractors fault (score = 0.25). V19 = 0.75.

7.3.5.3. V20: Cost overruns

Here, evaluation is best understood via perusal of the analysis sheet (Appendix F). Referee number 1 (V20a) cited a 40 percent overrun due to contractor claims (0.6[1 - 0.4] x 0.5 = 0.3) and referee number 2 (V20b) witnessed no overrun at all. Hence, (0.3 + 0.5) so V20 = 0.8.

7.3.5.4. V21: Actual quality achieved

Cr1 was awarded ratings of 8 and 9 from each referee respectively. Therefore V21 score (mean) = 0.85.

7.3.6. Interim discussion -P1 analysis

Hereafter, the alpha-numeric references eg., {B7} refer to the spreadsheet cells in the Cr_1 spreadsheet analysis (Appendix N). That is, {B7} identifies the cell in column B, row 7.

As shown in appendix N, the variable scores V_i awarded to Cr_1 above, have been carried to the summary {C7 to C12, C21 to C24, C33 to C36, C45 to C47, C56 to C59} and multiplied by their relevant weighting indices {D7 to D12, D21 to D24, D33 to D36, D45 to D47, D56 to D59}. This produces a rationalised score for each variable {E7 to E12, E21 to E24, E33 to E36, E45 to E47, E56 to E59}.

By dividing the sum of rationalised scores for a given factor {eg., E13} by the sum of maximum attainable rationalised variable scores for the same factor {D13}, a factor score is produced {E15}. This allows perusal of each factor score for signs of specific weakness (refer to section 5.6.1. earlier). We may observe Cr_1's factor scores in Table 7.1.

Table 7.1.
Cr_1 -P1 factor scores achieved

Factor	Factor score	Expressed as percentage	Rank
Organisational structure	0.887	88%	1
Financial stability	0.767	76%	5
Management resource	0.820	81%	3
Past experience	0.793	79%	4
Past performance	0.858	85%	2

The maximum possible factor score achievable is 1.0. This is why these scores are also expressed as a percentage in Table 7.1. that is, they may be easier perceived in percentages. Although financial stability ranks lowest with a factor score of 0.76 (76%), none of the scores give apparent cause for concern. Not having eliminated Cr_1 at this stage we may now compute the P1 score;

By establishing Z1 score ie., the sum of rationalised scores {E13 + E25 + E37 + E48 + E60} and, dividing this by Z1Max ie., the sum of W_i {D13 + D25 + D37 + D48 + D60}, then the contractor achieves an overall P1 score of 0.82 {C68}. This may be expressed as the contractor exhibiting an overall P1 potential performance score of 82% again, expressed in terms of a percentage for similar reasons to that described above.

We will assume for the purposes of this worked example that this score leads to the contractor receiving an invitation to tender and, will therefore subsequently be subjected to P2 analysis. Obviously, where several contractors have undergone P1 analysis then selection of tenderers will be primarily dependent upon their scores relevant to each other.

7.4. EVALUATING PROJECT SPECIFIC ATTRIBUTES -P2 ANALYSIS

Having been invited to tender, evaluation of the contractor in relation to more specific factors may now commence.

7.4.1. Factor: Project specific variables

7.4.1.1. V22: Geographic experience

Cr_1 has furnished details: (contract completed 14 months ago, duration eleven months, located within an area delineated by a 25 mile radius of the proposed project). This complies with the requirements of V22, so score = 1.0.

7.4.1.2. V23: Experience of a similar construction

Cr_1 has provided details of contracts executed within the last two years, confirming experience in eight of the ten specific work categories chosen by the practitioner. Hence, (8 x 0.1) V23 = 0.8.

7.4.1.3. V24: Plant policy

The contractor has indicated reasonable perception of the major plant requirements for the project (score 0.5). However, the firm pursues an 'all own' policy (score 0.25). V24 is therefore 0.75.

7.4.1.4. V25: Key persons available for project

Practitioner / client management requirements have been established as: *2 senior managers* (contracts manager and site manager), *3 first line managers* (general foreman and two trades foremen). The contractors' proposed management structure is: *2 senior, 2 first line.*

Hence: [0.5(2/2) + 0.5(2/3)] = V25 = 0.83.

7.4.1.5 V26: Qualification of key persons available

Measures of management performance potential are those utilised under V12. The management team proposed by the contractor are shown to be well qualified. This correlates with the good training provision identified earlier under V14. However, only one manager has overseas experience.

Therefore, [3(0.25[5/5]) + 0.25(1/5)] = V26 = 0.8.

7.4.2. **Factor: Other specific variables**

7.4.2.1. V27: Current workload

The contractors current workload is;

Contract (a) value £360,000 contract period 12 months

Contract (b) value £140,000 contract period 10 months

Contract (c)* value £36,000 contract period 6 months

**to be commenced during life of proposed project.*

Based on this, approximation of the contractors current maximum financial outlay is;

		£ '000
(a)	2(360/12) =	60,000
(b)	2(140/10) =	28,000
(c)	2(36/6) =	12,000
		£100,000

To this is added Cr_1's tender for the proposed project (project value £486K, contract period 10 months) ie;

2(486/10) =	97,000
current workload B/F	100,000
Maximum Financial Commitment	£197,000

From V1 earlier, gross (unmodified) maximum financial capability (MFC) is £210K so because MFO (£197K) is below MFC (£210K) then V27 = 1.0.

7.4.2.2. V28: Prior relationship

The client *has* dealt with the contractor before and from the rating of 6 awarded by the client then V28 = 0.6.

7.4.2.3. V29: Home office location in relation to project

The proposed project does come within an area defined by a 25 mile radius of the contractors nearest local, or head office. Hence V29 = 1.0.

7.4.3. Interim discussion -P2 analysis

From the spreadsheet analysis in Appendix N, it can be seen that as per P1 analysis all variable scores (V_k) have been carried to the summary {K7 to K11, K21 to K23} and multiplied by their relevant weighting indices (W_k) {L7 to L11, L21 to L23}. In addition, these are now multiplied by their relevant utility weights (U_k) {M7 to M11, M21 to M23}. It can be seen that all variables maintain a utility of 1.0 excepting plant resource (0.9), prior relationship (0.7) and office location (0.6).

Similarly, as per P1, factor scores may now be perused for signs of weakness but none seem apparent; *project specific* score is 0.81 and *other specific* score is 0.7. The sum of rationalised variable scores under each factor {N12 + N24} divided by the sum of weighting indices for each factor {L12, L24} achieves a P2 score of 0.766 {K32}, which may be expressed as the contractor having a project specific potential performance score of 76% {K33}.

As intimated in chapter 6, the effect of the utility coefficient on P2 analysis is to accentuate those contractors' P2 scores -who have performed well under variables perceived as important by the client, and vice-versa. The resultant effect of these utility coefficients on the P2 score is worthy of more detailed examination.

Assume a contractor has been evaluated and has achieved P2 variable scores as shown in column 1 of Table 7.2;

Table 7.2.
P2 variable scores and high / low correlating utility weights

Variables	Scores[1]	Column 2	Column 3
V22: Experience geographic	0.95	1.00	0.75
V23: Experience work elements	0.60	0.70	1.00
V24: Plant policy	0.50	0.75	1.00
V25: Key persons available	1.00	0.90	0.60
V26: Qualification key persons	1.00	1.00	0.40
V27: Workload capacity	0.70	0.60	0.90
V28: Prior relationship	0.50	0.40	1.00
V29: Office location	1.00	1.00	0.70

[1] Variable scores achieved by contractor

Between columns 1 and 2 there is a high degree of correlation between selection variables in which the contractor has scored well and has high utility weights (coefficient 0.78). Between columns 1 and 3 the same utility weights are utilised but their redistribution means that the coefficient is lower (-0.96).

We may now observe two scenarios;

Scenario one

Assumes that the contractor has scored well in those variables perceived as important by the client ie., there is strong correlation (coefficient = 0.78) between *high* variable scores (column 1) and high utility weights (column 2).

Scenario two

Assumes that the contractor has not scored so well in those variables perceived as important by the client ie., there is strong correlation (coefficient = -0.96) between *low* variable scores (column 1) and high utility weights (column 3).

P2 score calculations for both the above scenarios are shown in Tables 7.3. and 7.4. respectively.

Table 7.3.
P2 score calculation.
Correlation between high variable and high utility scores

Variable	V score	Weight	Utility	Rational score
V22: Experience geographic	0.95	0.409	1.00	0.388
V23: Experience work elements	0.60	0.564	0.70	0.236
V24: Plant policy	0.50	0.486	0.75	0.182
V25: Key persons available	1.00	0.547	0.90	0.492
V26: Qualification key persons	1.00	0.673	1.00	0.673
		2.679		1.971
Factor score = 1.971/2.679 = 0.735				
V27: Workload capacity	0.70	0.862	0.60	0.362
V28: Prior relationship	0.50	0.651	0.40	0.130
V29: Office location	1.00	0.642	1.00	0.642
		2.155		1.134
Factor score = 1.134/2.155 = 0.526				

Z2score = (1.971 + 1.134) = 3.105. Z2Max = (2.679 + 2.155) = 4.834.
Therefore, P2 score = 3.105 / 4.834 = 0.642 or 64%

Table 7.4.
P2 score calculation.
Low correlation between high variable and high utility scores

Variable	V score	Weight	Utility	Rational score
V22: Experience geographic	0.95	0.409	0.75	0.291
V23: Experience work elements	0.60	0.564	1.00	0.338
V24: Plant policy	0.50	0.486	1.00	0.243
V25: Key persons available	1.00	0.547	0.60	0.328
V26: Qualification key persons	1.00	0.673	0.40	0.269
		2.679		1.469
Factor score = 1.469/2.679 = 0.548				
V27: Workload capacity	0.70	0.862	0.90	0.543
V28: Prior relationship	0.50	0.651	1.00	0.325
V29: Office location	1.00	0.642	0.70	0.449
		2.155		1.317
Factor score = 1.317/2.155 = 0.611				

Z2score = (1.469 + 1.317) = 2.786. Z2Max = (2.679 + 2.155) = 4.834.

Therefore, P2 score = 2.786 / 4.834 = 0.576 or 58%

It can be seen that a higher P2 score (64%) is achieved by the contractor who has high variable scores for those criteria perceived as important by the client. Conversely, a lower P2 score (58%) is yielded for the contractor who does not score well in these same criteria. In short, a contractor exhibits greater potential for achieving client satisfaction (ie., a higher P2 score) where high variable scores are achieved in those selection criteria *that the client perceives as important to his particular project.*

A further important point is that albeit two contractors may have almost identical V scores, it is the contractor who matches high V_k scores to those areas perceived as important by the client, that will achieve the better P2 score.

7.5. FINAL SELECTION -P3 SCORE

The formula for P3 score is 0.6 (bid score) + 0.4 (P2 score) when, bid score = lowest bid for project (£) divided by this contractors bid for project (£). (These ratios are based on earlier works concerned with tender evaluation -see Hawwash 1991A; 1991B. Chapter 8 later investigates the sensitivity of P3 score using alternative P3 coefficients). If we assume that the lowest bid submitted for the project is £475K, then bid score for Cr_1 = (£475K/£486K) = 0.977 {K44}.

Therefore, the P3 calculation is (0.6 x 0.977) + (0.4 x 0.76) = 0.890 {K46}.

This may be expressed as contractor Cr_1 exhibiting an 89% overall potential performance score, in terms of meeting, time, cost and quality standards, based on the thorough three stage process of evaluation elucidated above.

Having followed the fortunes of one particular contractor from invitation to prequalify through to final P3 score, we may now explore how Cr_1 compares relative to the other five contractors who were invited to tender.

Table 7.5. exhibits P2 scores achieved and, tender sums submitted by all six contractors (Cr_1, Cr_2,....Cr_6) competing for the award.

Table 7.5.

P2 Scores / bid scores for all tenderers

Contractor	P2 score	P2 rank	Bid £	Bid rank
Cr_1	0.766	1	486	5
Cr_2	0.612	5	478	2
Cr_3	0.380	6	475	1
Cr_4	0.720	2	487	6
Cr_5	0.637	4	479	3
Cr_6	0.704	3	480	4

It is worth noting at this point, that under *current selection practice* Cr_3 is most probable for award of the contract on the basis of having submitted the lowest bid. However, by applying this alternative selection technique it is shown that the same firm has less performance potential, as evidenced by Cr_3's P2 score (lowest achieved amongst the group at 0.38). In contrast, Cr_1 ranks last-but-one on the basis of cost alone and would therefore, be unlikely to achieve the contract under present selection methods. However, Cr_1 achieved the largest P2 score (0.766).

To progress with P3 comparison bid scores may now be calculated for each contractor by the formula: lowest bid submitted for this contract / this contractors bid). All bid scores are shown in Table 7.6.

Table 7.6.
Contractors bid scores

Contractor	Lowest bid / this bid	Bid score
Cr_1	475 / 486	0.977
Cr_2	475 / 478	0.993
Cr_3	475 / 475	1.000
Cr_4	475 / 487	0.975
Cr_5	475 / 479	0.991
Cr_6	475 / 480	0.989

All that now remains is to carry forward P2 scores from Table 7.5. and perform the P3 calculation for all tenderers.

Albeit Cr_1 ranked fifth on bid value alone (refer table 7.5.) P3 scores confirm that the contractor now ranks highest overall and would therefore under this method, be most eligible for award of the contract (Table 7.7). Indeed, the lowest tenderer has been relegated to lowest rank because of the poor P2 score.

The example given is somewhat contrived, but it has shown that the model has achieved its aims and identified;

a) the best all round contractor for the project;
b) the 'unscrupulous' contractor who submitted a low bid but exhibited greater probability of generating problems for the client en-route to completion of the contract.

Table 7.7.
P3 Calculation for all tenderers

Contractor	P2 element		Bid score element		P3 score	Rank
Cr_1	(0.766 x 0.4)	+	(0.977 x 0.6)	=	0.889	1
Cr_2	(0.612 x 0.4)	+	(0.993 x 0.6)	=	0.840	5
Cr_3	(0.380 x 0.4)	+	(1.000 x 0.6)	=	0.752	6
Cr_4	(0.720 x 0.4)	+	(0.975 x 0.6)	=	0.873	3
Cr_5	(0.637 x 0.4)	+	(0.991 x 0.6)	=	0.849	4
Cr_6	(0.704 x 0.4)	+	(0.989 x 0.6)	=	0.875	2

7.5.1. Bid evaluation -incorporating the time value of capital

In the above example, the financial ranking of bids was based on the sole criterion of tender figure, but (particularly for longer contracts) the practitioner may wish to consider the extra dimension of time. As Hardy et.al. (1981) pointed out; "The lowest bid does not necessarily give the best return on the investment since the bid represents a series of payments over time" (see also Smit, 1979; Vorster, 1977; Hawwash, 1991A; Mott, 1992). Such an evaluation is termed a 'discounted cashflow analysis'.

In taking account of the time value of capital there are further factors that the practitioner may wish to consider. These factors are a function of the given project characteristics and may include;

a) tender cash flow -this is best analysed by establishing the cumulative cash flow ie., 'S' curve (Smit; Hardy et.al.);

b) price adjustment -where a fluctuation contract is used the client may wish to estimate the anticipated escalation rate and observe its effect upon cashflow;

c) positive cash flow(s) -which may be derived from early completion eg., where the project is built to generate revenue. Where this is not the case it may be reasonable to consult liquidated damage clauses for guidance, these being (or should be) a reasonable assessment of the damages the owner will suffer from late completion (ie., therefore must be a guide to positive cash flows resulting from early completion).

Finally, miscellaneous factors such as mobilisation payments, site establishment costs and retention monies may all have some influence on financial evaluation. Table 7.8. summarises these considerations.

An example of such an evaluation may be given for one of the above tenderers (in practice the analysis must be applied to all bids under consideration). Consider contractor Cr_1; tender figure is £486K and construction period is nominated by the contractor as nine months.

Figure 7.1. shows the anticipated cumulative cash flow as indicated by the contractor and endorsed by the practitioner. Due to the contract size / period, the effects of price escalation are ignored and constant prices are used. No allowance for retention is made and payment is inserted at month end. Analysis of Cr_1's anticipated payments are shown in Table 7.9.

Table 7.8.
Independent variables -time / cost evaluation of bids

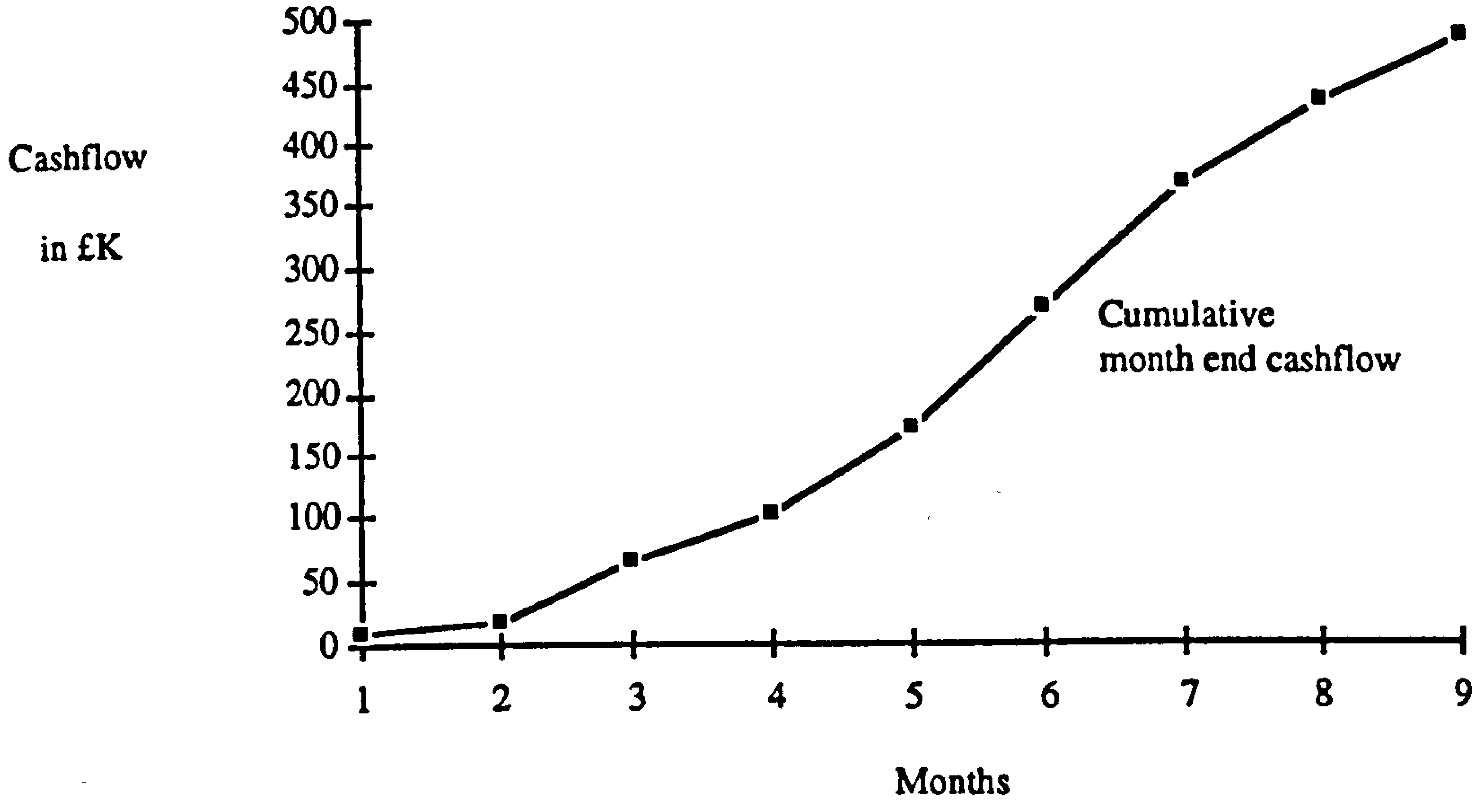
Variable	Controlled by	Comments
Project time horizon	Contractor / client	May be unique to each bid. Reasonable assessment; longest period nominated by any one contractor. Contractors to nominate period where applicable
Cumulative cash flow	Contractor	Unique to each bid. Contractors should indicate programme / anticipated cashflow as owner may derive S curve for each tender
Price adjustment factor	Economic environment	Common to all bids. Subjective estimation required by client/practitioner based on present / forecast economic factors
Positive cash flows	Clients circumstances	Magnitude common, timing dependent upon completion date. Client should quantify positive effect of early completion. May look to liquidated damages for guidance but this is dubious
Cost of capital	Client	Common to all bids. May be 'opportunity' cost. Client may wish to nominate rate to be used

Adapted from Vorster 1977.

Table 7.9.
Anticipated payment cashflow - Cr_1

Month number	Monthly cash flow	Monthly percentage	Cumulative cashflow	Cumulative percentage
1	10	2.0	10	02.0
2	7	1.4	17	03.4
3	50	10.2	67	13.7
4	33	6.7	100	20.5
5	69	14.1	169	34.7
6	99	20.3	268	55.1
7	98	20.1	366	75.3
8	70	14.4	436	89.7
9	50	10.2	486	100.0

Figure 7.1.
Cumulative cashflow curve - contractor Cr_1



Based on the above cashflow and assuming;

a) that the time horizon is ten months (longest construction period nominated amongst all tenderers);

b) that a positive cash flow accrues to the client of £5K per month for completion within this time horizon;

c) that the client's cost of capital is 12 percent.

Then a discounted cash flow analysis may be performed as shown in table 7.10.

Table 7.10.
Discounted cashflow analysis - Cr_1

Month number	Negative flow	Positive flow	Monthly P.V. factor @ 12% [a]	N.P.V [b]
1	(10)	*	0.9906	(9.906)
2	(7)	*	0.9813	(6.869)
3	(50)	*	0.9721	(48.605)
4	(50)	*	0.9629	(31.77)
5	(69)	*	0.9539	(65.819)
6	(99)	*	0.9449	(93.545)
7	(98)	*	0.9360	(91.728)
8	(70)	*	0.9272	(64.904)
9	(50)	*	0.9185	(45.925)
10	*	5	0.9099	4.549
			Σ N.P.V. =	**(454.627)**

[a] *Present value of £1 at monthly intervals from the base date, assuming 12% inflation rate.*

[b] *Net present value of monthly (negative) cashflow to client.*

For this particular contractor the Net Present Value (N.P.V.) of the tender (cf. Mott, 1992) is minus £454. A similar analysis may be performed for all tenderers (Cr_1 - Cr_6) the smallest NPV identifying the most attractive bid; "The successful bid should require the lowest net present value of payments from the client at a discount rate specified by the client" (Hawwash, 1991A).

Having executed this analysis, each tenderers NPV may then be converted to a bid score for inclusion in P3 analysis via the formula; Lowest NPV/This contractors NPV (for all bids under review).

The given example of time / value analysis is only an outline, a voluminous amount of literature abounds characterising all possible ramifications of discounting techniques.

It has been shown however, that the time / value consideration of bids may be incorporated *into* the model. The variables considered in such analysis are at the discretion of the practitioner taking into account the particular circumstances pertaining to the project.

7.6. SUMMARY

An alternative selection method has been described based on the three stage model described earlier.

It has been shown by application of the model in an hypothetical selection scenario, that it is not necessarily the lowest bidder that achieves award of the contract, but rather, that contractor exhibiting most all-round performance potential.

The model may also take account of discounting techniques where the time value of bids must be considered.

CHAPTER 8

VALIDATION OF THE MODEL

8.0. INTRODUCTION

This chapter presents analyses and results, arising from application of the developed technique to live contractor selection exercises. Applications were facilitated by working closely with collaborating construction owners, two of whom became particularly involved with the work namely; Waveney District Council (WDC) and Severn Trent Water Authority Plc (STWA). Both owners expressed benefit from the research with the former adopting the technique almost in its entirety (Appendix A).

Comparison of model outputs with contractor competence / performance was achieved by requesting clients to furnish past performance ratings for each of the firms evaluated (before being exposed to any evaluation results!). These ratings were then contrasted with V_i / V_k, *PFS* / *T*FS, P1, P2 and P3 components. Analysis of model outputs identified central tendencies amongst contractor types. Correlation tests yielded levels of association between contractor attributes; enhancing understanding of contractors' organisational interrelationships. The Chapter validates the model and confirms an output mechanism able to identify, indeed highlight, *key* contractor characteristics. Finally, the statistical technique of cluster analysis confirmed model ability to correctly classify 'good' and 'not so good' contractor types.

8.1. CASE STUDIES A TO C

Each individual selection exercise was referred to as a case study ie., case studies A to D. Because of the confidential nature of contractor input data, anonymity of firms has been respected -a method of identification gives each contractor a unique reference ie., Cr is followed by a number (identifying the contractor) and a letter (depicting the case study). For example, Cr1A refers to contractor 1 case study A, Cr2B refers to contractor 2 case study B and so on.

Waveney District Council (WDC) is a public sector client who having expressed interest in the research at an early stage, subsequently agreed to participate in validation of the model. Three WDC case studies form the main sample, with the STWA sample contributing to P2 validation later in the Chapter.

The WDC sample comprised contractors competing for three separate projects: A, B & C. Contract values ranged from £150,000 to £250,000 with contract periods ranging from 4.5 to 6 months. The projects were predominantly conversion and refurbishment, based within Norfolk and Suffolk.

A standing list was not used -each project was advertised in the press inviting contractors to prequalify. To collect contractor information, WDC utilised the pro-forma questionnaires introduced in Chapter 7. That is, all contractors desirous to tender completed a *prequalification questionnaire* (Appendix J). Firms subsequently invited to tender had to further complete a *tenderer evaluation questionnaire* (Appendix K). Client utility values were collected via the client questionnaire (Appendix L).

Amongst these three case studies, eighteen contractors were prequalified that is, subjected to P1 analysis. Just over two thirds of this original sample went on to tender for the three projects. Hence, thirteen firms were subjected to P2 analysis and thereafter also awarded a P3 score.

Notwithstanding the WDC projects being small, involvement of this client facilitated full application of the technique and interpretation of the model outputs over a shorter time scale. Clearly, due to the practical nature of the model each complete application was a time consuming procedure.

The WDC sample are detailed in Table 8.1. It can be seen that only one contractor relates to case study A. This is because only one *duly completed* prequalification questionnaire was received. Such a negative response was a result of the client *inviting,* not *requesting,* formal prequalification information from contractors desirous to tender for this project.

Table 8.1.
Composition of the WDC sample

	Contractors prequalified		Tenderers evaluated	
Contract	Number	%	Number	%
Case study A*	1	5	1	7
Case study B†	8	45	8	62
Case study C††	9	50	4	31
Totals	18	100%	13	100%

* *One firm only -refer to text*
† *All firms prequalifying were invited to tender*
†† *'Best' four firms only, were subsequently invited to tender*

Albeit initially disappointing, this confirmed a very important point;

> *where a formal selection procedure is being implemented then a structured data collection approach*[1] *must be adopted. Further, it must be clear to the contractor that completion of the data collection document is requisite, should the firm wish to be given subsequent consideration by the client.*

[1] In this instance the formal approach involves the prequalification questionnaire, however, inevitable computerisation of the process will render the diskette commonplace. In any event, complete participation in supplying the necessary data to construction owners is a requisite component of a successful selection process.

In the present economic climate, clients have leverage to demand full participation of contractors in the selection process -such is the competition for work. This position may change in tandem with market forces. However;

i) contractors have a duty to comply with reasonable requests for information but;
ii) a rationalised selection procedure would ensure that informational demands on the contractor are not excessive (cf. Latham, 1994A) and;
iii) a standard procedure throughout the industry would mean that contractors have to comply, no matter who the client (Holt et al, 1993B).

Incidentally, can a client be confident that questionnaire responses are unambiguous, that is, can a contractor be dishonest and get away with it?

Undoubtedly, it is difficult to verify all responses entirely. However, WDC has embraced the new selection technique and so implements the two stage (prequalification / tenderer) evaluation process per project. This approach is generating WDC a data bank of contractor's attribute scores (V_i / V_k). By reference to this historical data, WDC has begun to identify misstatements made by firms competing for subsequent contracts.

Some of these misstatements have been serious. For example, one firm suddenly announced that it had gained Chartered Building Company status (CIOB, 1992) which turned out to be untrue. In view that some contractors appear willing to proclaim invalid statements in an attempt to gain work, a similar (retrospective) approach to that being adopted by WDC would need to be mirrored by clients, should contractor selection become standardised (cf. Latham 1994A). This is because a standard qualification questionnaire[2] would mean contractors knowing in advance exactly what attributes are to be measured by the client.

[2] At this time the Construction Industry Board (formerly the Latham Review Implementation Forum), Working Group 5, are developing a standard qualification document for public sector work -see Latham, 1994B.

Perhaps here lies scope for further research eg., the development of a computerised data-base for retrospective validation of contractor prequalification data. Some policing of responses is essential to ensure selection based on 'truth'.

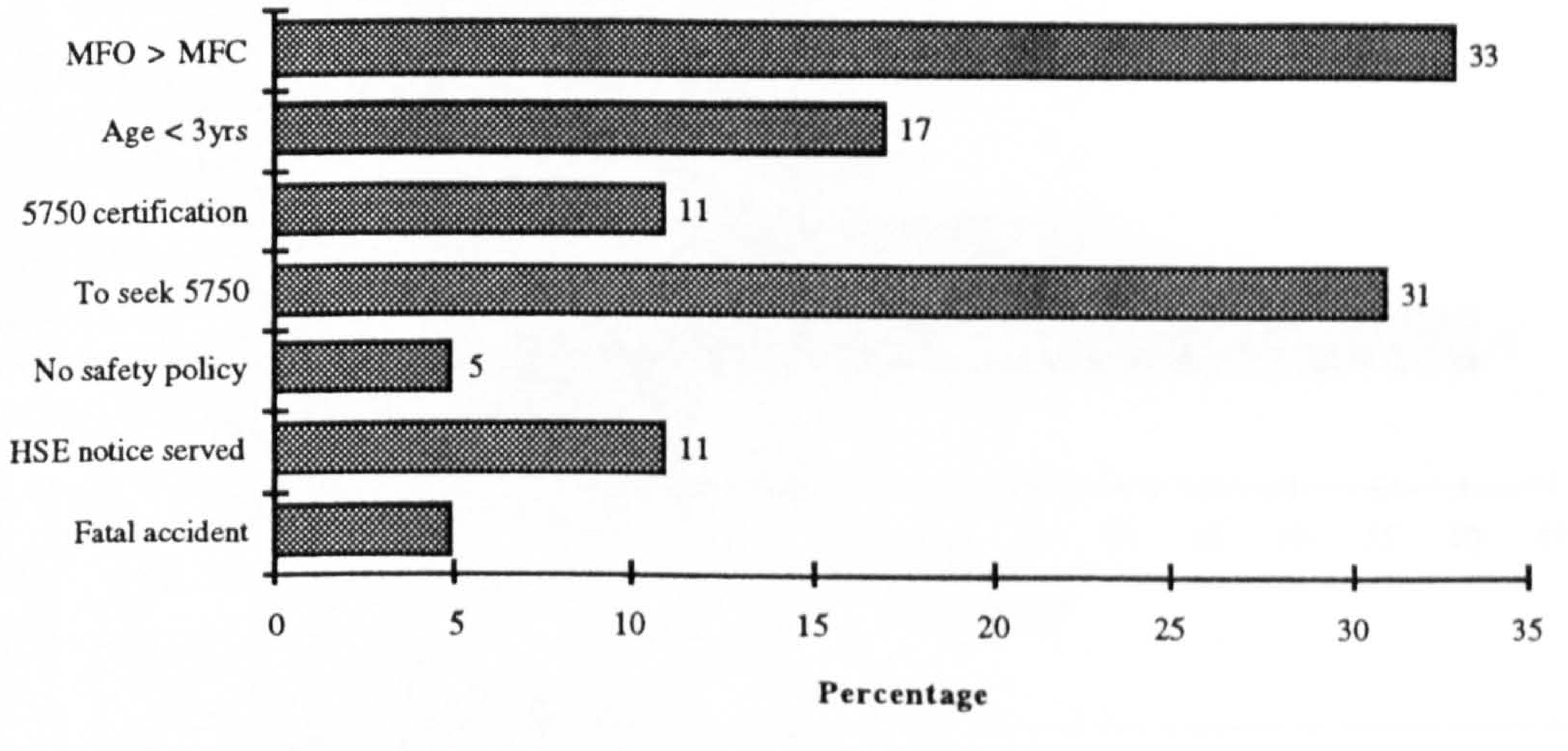
8.1.1. Initial trends and observations amongst the sample

Prior to quantitative analyses of attribute scores later, the following narrative is a discussion; of how contractors fared during evaluation to offer a 'feel' for the sample. This also confirms model ability to highlight salient contractor characteristics.

8.1.1.1. Organisational attributes

From calculation of MFO and MFC it was apparent that financial capacity in respect of the project out to tender, was questionable in the case of one third of all contractors. Regarding age, 17 percent had traded for less than three years. Only 11 percent of firms were B.S. 5750 certified, of the remainder, 31 percent indicated the intention to apply for such certification within the next six months (here is a perfect example of scope for retrospective comparison of attributes ie., did they apply?).

Figure 8.1.
WDC sample: organisational attributes



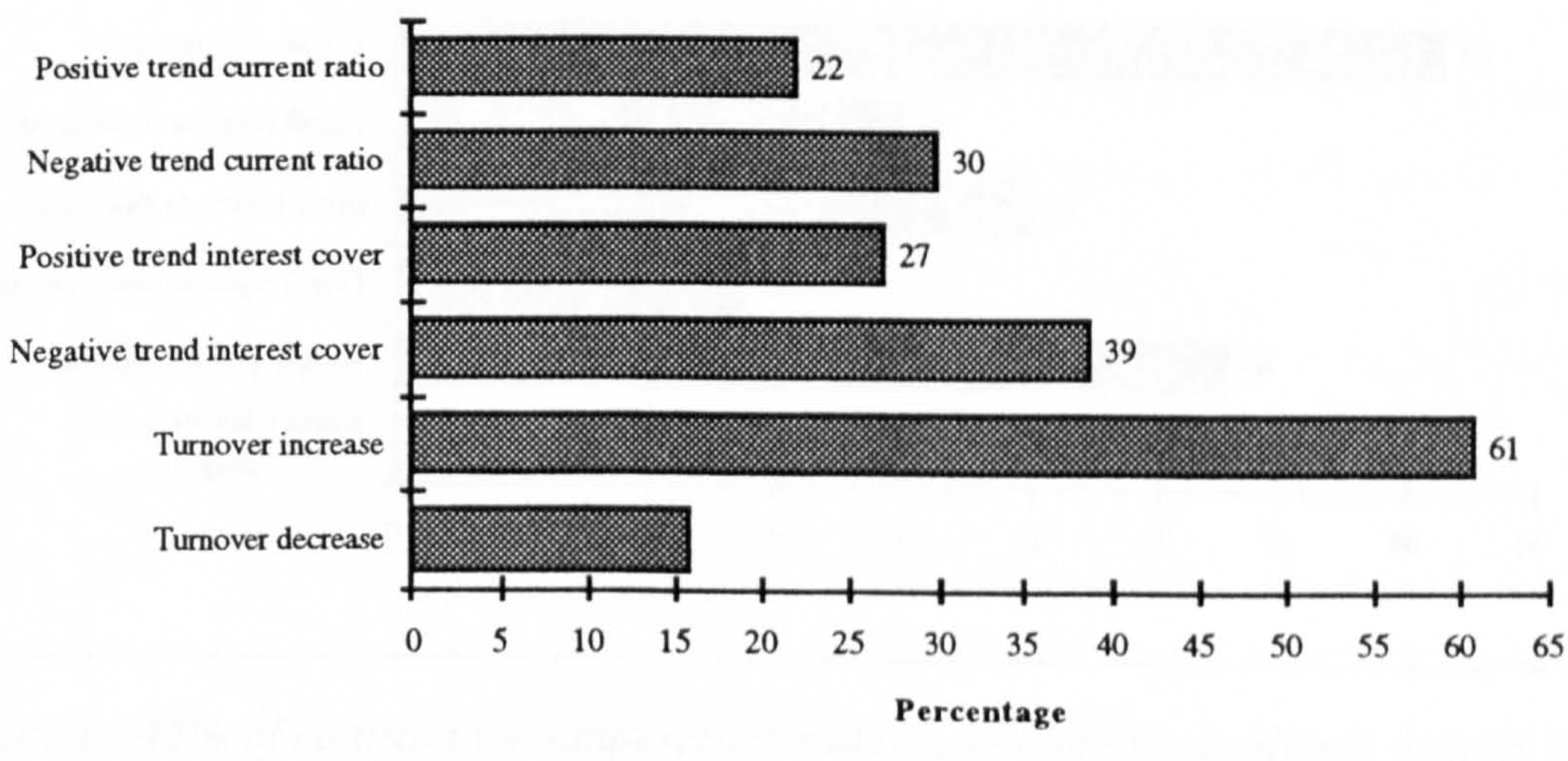
One company admitted to not having a formal safety policy -in contravention of HASWA 1974. Eleven percent had been served a Prohibition Notice by the Health & Safety Executive within the last three years, whilst one company had witnessed a fatal accident upon a construction site during the same period.

8.1.1.2. Financial attributes

Regarding the three years previous trading, 22 percent of contractors exhibited a chronological positive trend for the current ratio (current assets / current liabilities). Thirty percent experienced the opposite. Twenty seven percent had a chronological positive trend for interest cover (interest payable on loan capital as a ratio of pretax profit), with 39 percent witnessing the opposite. Sixty one percent had consistently increased their turnover whilst 16 percent had consistently decreased.

For each of these financial measures the remainder of the sample fluctuated - see Figure 8.2.

Figure 8.2.
WDC sample: financial attributes

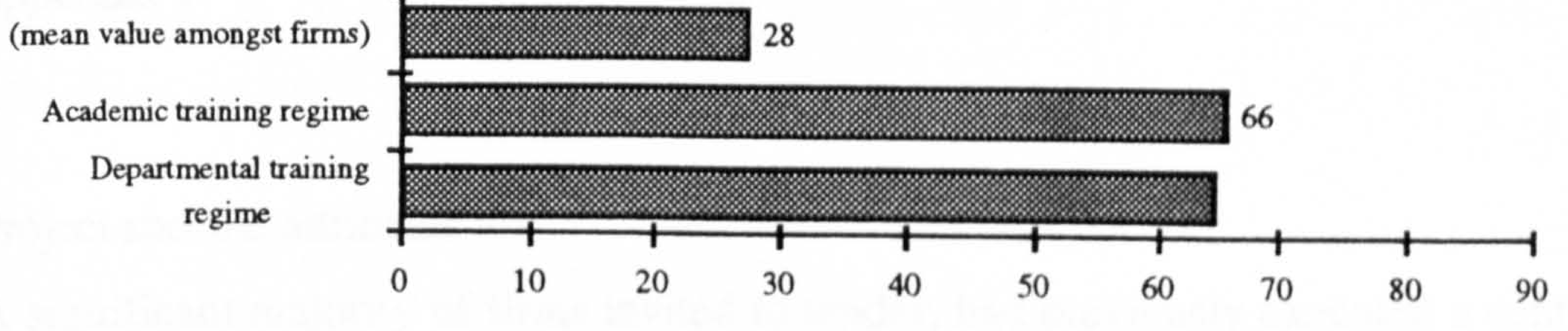


8.1.1.3. Management attributes

Fifty five percent of all management staff did not hold an academic degree. Amongst those firms whose managers did hold a degree, the mean value was 25 percent. Seventeen percent had no managers between the age range 30 to 40 years. Amongst those contractors with managers within this optimum age band (Mustapha, 1990) the mean proportion was 40 percent.

Exactly half of all contractors had no managers with Chartered status (eg., M.C.I.O.B. or M.I.C.E.), the remaining half exhibited a mean value of 28 percent of managers with this characteristic. Seventeen percent of firms had managers with overseas construction experience. Two thirds of all contractors operated academic training for their managers with 65 percent offering internal departmental experience as an alternative or compliment to such training - Figure 8.3.

Figure 8.3.
WDC sample: management attributes

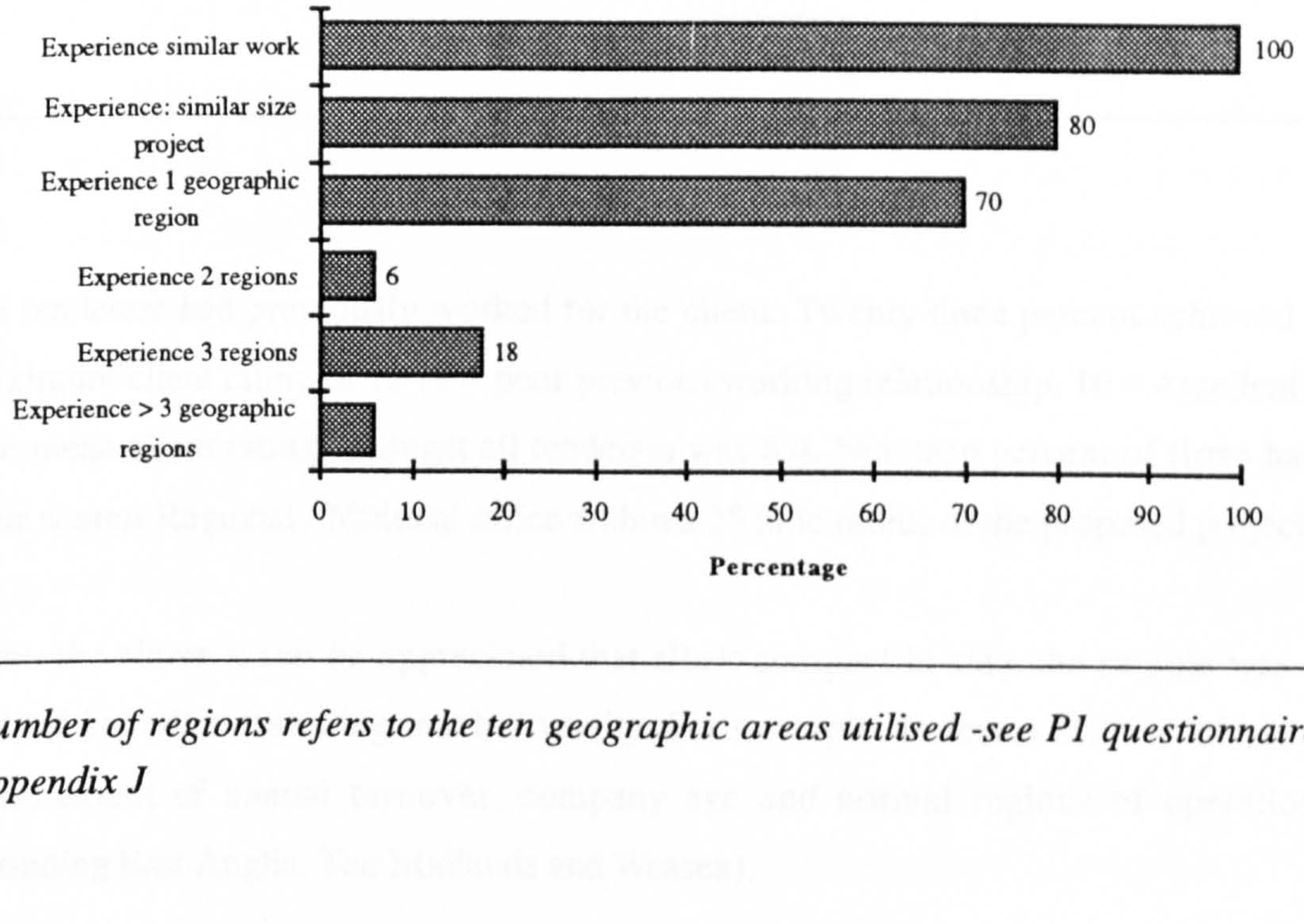


Example: 45% of contractors employed managers holding an academic degree. The mean value amongst these firms was 25%.

8.1.1.4. Experience attributes

The entire sample confirmed having executed similar work within the last two years, to that being tendered for. Eighty percent had executed a contract of similar size (£) within the same period. Analysis of geographic experience, pointed towards all but 11 percent of firms as being 'local' companies -see Figure 8.4. Overall *performance* ratings for each of the contractors are discussed later.

Figure 8.4.
WDC sample: experience attributes

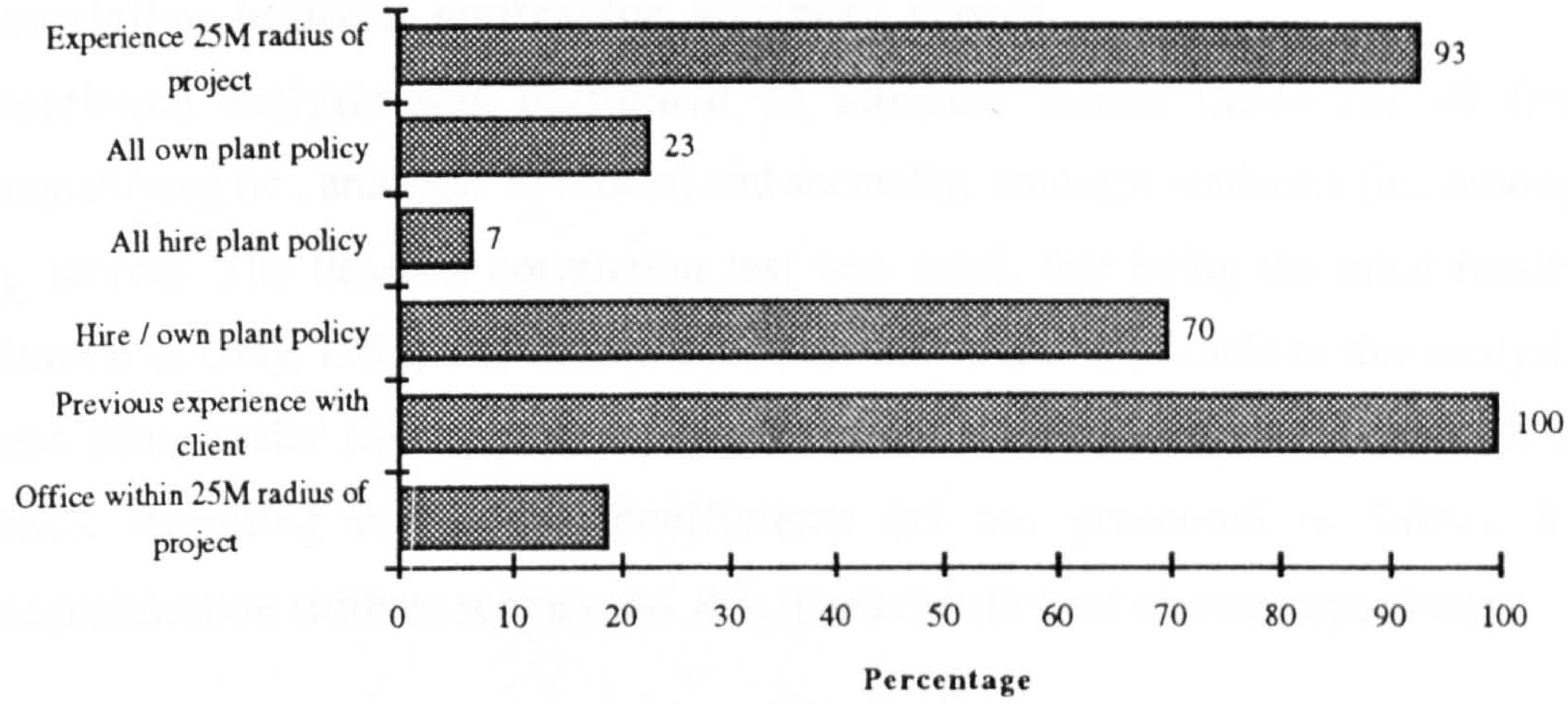


Number of regions refers to the ten geographic areas utilised -see P1 questionnaire Appendix J

8.1.1.5. Project specific attributes

A significant majority of firms invited to tender, had previously executed a contract within a 25 mile radius of the proposed project. Regarding plant procurement, 23 percent had an "all own" policy, 7 percent opted for "all hire" the remainder utilised a mix of these two options, see Figure 8.5.

Figure 8.5.
WDC sample: project specific attributes



All tenderers had previously worked for the client. Twenty three percent achieved a maximum client rating of 10 (1 = poor previous working relationship, 10 = excellent). The mean client rating amongst all tenderers was 8.4. Nineteen percent of firms had their nearest Regional / National office within a 25 mile radius of the proposed project.

From the above it can be appreciated that albeit compact in size, the sample was a 'mixed bag' demonstrating much diversity. For example, in terms of: size of asset base, extent of annual turnover, company age and normal regions of operation (spanning East Anglia, The Midlands and Wessex).

8.1.2. Analysis of attribute scores achieved

Having observed prominent characteristics of the WDC sample, the degree of association between attribute scores achieved, was investigated. Following this, measures of central tendency and dispersion were examined both amongst the sample as a whole and amongst segregated sets in terms of; 'good' / 'not so good' contractors (as defined by client's past experience with the firms) and amongst those contractors submitting the highest and lowest bids for the projects studied.

8.1.3. Association between contractor attribute scores

Correlation analysis was performed on attribute scores firstly for all firms prequalifying (ie., amongst V_i scores) and secondly, amongst tenderers (ie., amongst V_k scores). The Pearson correlation test was used, this being the most familiar (Kinnear & Gray, 1992) and able to deal with the values applicable to this analysis - these being scalar (interval) data. The SPSS statistical package was used (SPSS, 1986). Resulting correlation coefficients (r) are presented in Tables 8.2. (prequalification attribute scores) and 8.3. (tenderer attribute scores) respectively.

Caution prevails within the discussion as not to confuse 'association' and 'causation'. Notwithstanding that association may exist between attribute scores, it does not automatically follow that one is the cause of the other. However, logical interpretation of positive / negative association is given.

8.1.3.1. Prequalification criteria

The first point of note from Table 8.2. is that r has not been computed for V18 *failure to have completed a contract*. This is because all of the sample achieved a maximum score of 1.0 for this criterion ie., no contractor indicated previous non-completion.

Secondly, it can be seen that 95% and 99% confidence levels (p) have been identified (coefficients on the Table single underlined and double underlined respectively). The following discussion considers coefficients where $p \geq 99\%$.

V1 *size* and V5 *Health & Safety regime* ($r = 0.63$, $p = 0.005$) would indicate that contractors with greater financial assets (ie., a high attribute score in *size*) would probably commit adequate resources to health & safety (H&S). Conversely, reduced financial resources may mean lower priority towards H&S obligations.

Table 8.2.

Correlation matrix -results on prequalification criteria case studies A, B, & C

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}
V_1	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_2	-0.35	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_3	0.12	0.47	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_4	0.41	0.10	0.05	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_5	0.63	-0.22	0.01	0.30	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_6	0.09	0.28	0.43	0.18	0.18	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_7	0.26	0.04	-0.18	0.27	0.50	-0.03	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V_8	0.40	0.13	0.19	0.59	0.31	-0.12	0.17	1.00	.	.	.	.	.	.	.	.	.	.	.	.	.
V_9	0.50	0.16	0.19	0.26	0.44	0.24	0.36	0.60	1.00	.	.	.	.	.	.	.	.	.	.	.	.
V_{10}	0.61	-0.53	-0.36	0.41	0.48	-0.09	0.58	0.00	0.01	1.00	.	.	.	.	.	.	.	.	.	.	.
V_{11}	0.69	-0.29	-0.04	0.23	0.72	0.06	0.32	0.43	0.69	0.45	1.00	.	.	.	.	.	.	.	.	.	.
V_{12}	-0.16	-0.25	-0.37	0.12	0.00	-0.24	-0.01	0.05	-0.15	0.06	-0.04	1.00	.	.	.	.	.	.	.	.	.
V_{13}	0.05	0.04	0.11	-0.07	-0.25	0.23	-0.19	-0.08	0.04	-0.02	-0.05	-0.57	1.00	.	.	.	.	.	.	.	.
V_{14}	0.39	-0.22	0.08	0.36	0.18	0.11	0.30	-0.22	-0.16	0.68	0.07	0.16	0.00	1.00	.	.	.	.	.	.	.
V_{15}	-0.23	0.50	0.43	0.13	0.14	0.33	-0.02	0.19	0.01	-0.39	-0.15	0.02	-0.39	-0.29	1.00	.	.	.	.	.	.
V_{16}	0.01	0.31	-0.00	0.21	0.16	0.22	0.12	0.35	0.49	-0.09	0.33	-0.28	0.03	-0.49	0.38	1.00	.	.	.	.	.
V_{17}	0.38	-0.38	-0.05	0.57	0.43	0.25	-0.01	0.57	0.32	0.20	0.39	0.38	-0.20	-0.01	0.14	0.24	1.00	.	.	.	.
V_{18}	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	.	.	.
V_{19}	0.81	-0.17	0.11	0.37	0.48	0.01	0.16	0.58	0.71	0.36	0.83	-0.17	0.04	0.12	-0.32	0.19	0.34	†	1.00	.	.
V_{20}	0.49	-0.13	0.06	-0.17	0.44	0.27	0.39	0.21	0.60	0.17	0.56	-0.25	0.22	-0.15	-0.09	0.14	0.13	†	0.46	1.00	.
V_{21}	0.68	0.00	0.33	0.46	0.45	0.17	0.31	0.72	0.76	0.29	0.72	-0.26	0.22	0.07	-0.06	0.28	0.38	†	0.82	0.57	1.00

† = coefficient cannot be computed -refer to text

Single underlined = 95% 2 tailed significance

Double underlined = 99% 2 tailed significance

Regrettably, this is understandable (though not acceptable) in the current economic climate but nonetheless something practitioners should be aware of. Indeed, the increased responsibility placed upon contractors, as a result of the Construction Design and Management Regulations (CONDAM, 1995), make this 'negligent' approach high risk. Breach of the regulations is a criminal offence and as such lays the contractor open to prosecution.

Correlation between V1 *size* and V10 increasing *turnover history* ($r = 0.61$, $p = 0.007$) is logical. An expanding asset base (size) is a function of increasing turnover combined with healthy ROCE and sensible gearing (recall the latter two financial measures are a feature of *turnover history* evaluation in this instance).

Adequate resources are a function of prudent management, hence, V1: *size* and V11 *qualification of owners* ($r = 0.69$, $p = 0.001$). Likewise, such resources facilitate completion of the project on time (V1 *size* / V19 time *overruns* $r = 0.81$, p = absolute) and to desired quality (V1 *size* / V21 *quality record* $r = 0.68$, $p = 0.002$).

Contractors with BS 5750 / ISO 9000 quality accreditation are the ones achieving better bank references (V4/V8 $r = 0.59$, $p = 0.009$). The former attribute is also a feature of national, as opposed to local contractors (V4 *quality control policy* / V17 *catchment* $r = 0.57$, $p = 0.01$). Better health and safety policies are characteristic of those firms with qualified owners (V5/V11 $r = 0.72$, $p = 0.001$).

Positive association between V7 ratio analysis of accounts and V10 increasing turnover ($r = 0.58$, $p = 0.01$) is logical -one compliments the other. Growth is synonymous with increased profit and hence liquidity -albeit this is not always so (refer section 6.1.9.).

A good bank reference is a feature of those contractors who: have a larger catchment (V8/V17 $r = 0.57$, $p = 0.01$), complete projects on time (V8/V19 $r = 0.58$, $p = 0.01$)

and to desired quality (V8/V21 $r = 0.72$, $p = 0.001$), but not necessarily within budget (V8/V20 $r = 0.21$). Obviously claims (cost overruns) cause distaste to clients but apparently help keep Bank Managers satisfied!

Good creditor references are familiar to: contractors with qualified owners (V9/V11 $r = 0.69$, $p = 0.001$), a good time record (V9/V19 $r = 0.71$, $p = 0.001$) and better quality record (V9/V21 $r = 0.76$, p = absolute). It appears that superlative client requirements (time, cost, quality) are in part a function of *qualified owners*. That is, *qualified owners / minimal time overruns* ($r = 0.83$, p = absolute), *qualified owners / minimal cost overruns* ($r = 0.56$, $p = 0.01$), *qualified owners / good quality record* ($r = 0.72$, $p = 0.001$).

Contractors with better qualified managers have a higher turnover of staff (V12/V13 $r = -0.57$, $p = 0.01$). This could be a function of such managers being more able to move freely within the employment market and / or being headhunted.

Finally, the point made in Chapter 2 that time, cost and quality are not mutually exclusive (cf. BEDC, 1983) is borne out in that a good quality record shows correlation with good time performance (V21/V19 $r = 0.82$, p = absolute) and minimal cost overruns (V21/V20 $r = 0.57$, $p = 0.01$). The better time, cost and quality attribute scores show association with the following contractor attributes;

good time performance and,

- adequate resources
- financial stability (ratio analysis of accounts)
- good bank reference
- qualified owners

good cost performance and,

- qualified owners

good quality record and,

- adequate resources
- good bank reference
- good credit references
- qualified owners
- good time performance
- good cost performance.

8.1.3.2. Tenderer evaluation criteria

Correlation coefficients emanating from analysis of *tenderers* attribute scores (V_k) may be observed in Table 8.3.

Table 8.3.
Correlation matrix
-results on tenderer evaluation criteria case studies A, B, & C

	V22	V23	V24	V25	V26	V27	V28	V29
V22	1.00	.	.	.	.	.	.	.
V23	0.24	1.00	.	.	.	.	.	.
V24	0.06	-0.15	1.00	.	.	.	.	.
V25	-0.22	-0.16	0.47	1.00	.	.	.	.
V26	0.09	0.01	0.38	-0.50	1.00	.	.	.
V27	0.20	-0.36	0.58	0.34	-0.13	1.00	.	.
V28	-0.16	0.54	-0.26	-0.59	-0.48	-0.49	1.00	.
V29	0.30	0.25	-0.20	-0.29	-0.10	-0.29	-0.05	1.00

Albeit no significant correlations were identified, the negative aspect of V25 *key persons available* for the project and V28 *prior relationship* with the client ($r = -0.59$) is worth mention. This could indicate that where a poor previous relationship has occurred (ie., low client score) then the contractor is attempting to remedy this or avoid recurrence by ensuring adequate supervision is available for the forthcoming project (hence a high score in *key persons available*). Alternatively, a good previous relationship might have bred familiarity -with the contractor not being so concerned about adequate supervision this time around. Indeed, previous research has shown that former good contractor / client relationships are no measure for the future but rather, tend to breed familiarity and a degree of contempt on the part of contractors (Russell & Skibniewski, 1988; Janssens, 1991).

8.1.4. Statistical analysis of attribute scores achieved

To further the above insight into contractor attributes, descriptive statistics pertaining to scores achieved, were investigated. Table 8.4. exhibits statistics derived from the aggregated WDC sample data.

Column 1 shows maximum V score achieved amongst the sample with Column 2 exhibiting the converse. So for example, no contractor scored above 0.84 during ratio analysis evaluation, whilst none scored lower than 0.5 from evaluation of H&S policy. Column 3 exhibits the range this being the most simple measure of variability. The mean is shown in column 4. This measure of central tendency is complimented by the median in column 5 to offset the possibility of 'being misled' by the mean, in the case of extreme ie., very high / very low attribute scores. Finally, the standard deviation and variance are an observation on dispersion and variability of the data.

8.1.4.1. Discussion: all sample

Table 8.4. confirms a maximum score achieved on at least one occasion in all but eight criteria. Included in the eight are: V_7, V_8 and V_{10} these all being financial measures. The result mirrors financial fragility of contracting companies at this time and is compounded by the respective low mean / median values and limited dispersion. Neither was a maximum score achieved within V_{11} *qualification of company owners.*

Table 8.4.
Analysis of attribute scores case studies A to C
-central tendency and dispersion

	Max Value	Min Value	Range	Mean	Median	Stand. Dev'	Variance
PREQUALIFICATION VARIABLES							
V_1: Size of company	1.00	0.00	1.00	0.59	1.00	0.51	0.26
V_2: Age of company	1.00	0.00	1.00	0.82	1.00	0.39	0.15
V_3: Company image	1.00	0.00	1.00	0.68	0.50	0.35	0.12
V_4: Quality control policy	1.00	0.00	1.00	0.21	0.00	0.31	0.10
V_5: Health and safety policy	1.00	0.50	0.50	0.74	0.70	0.13	0.02
V_6: Litigation tendency	1.00	0.50	0.50	0.72	0.75	0.15	0.02
V_7: Ratio analysis	0.84	0.00	0.84	0.35	0.33	0.21	0.04
V_8: Bank reference	0.80	0.00	0.80	0.38	0.10	0.35	0.12
V_9: Credit reference(s)	1.00	0.00	1.00	0.58	0.80	0.35	0.12
V_{10}: Turnover history	0.75	0.00	0.75	0.34	0.25	0.28	0.08
V_{11}: Qualification -company owners	0.76	0.00	0.76	0.42	0.50	0.27	0.08
V_{12}: Qualification of key persons	0.47	0.00	0.47	0.17	0.15	0.15	0.02
V_{13}: Key persons yrs. with company	0.70	0.00	0.70	0.24	0.10	0.26	0.07
V_{14}: Formal training regime'	1.00	0.00	1.00	0.65	0.50	0.34	0.12
V_{15}: Type of past projects completed	1.00	0.00	1.00	0.93	1.00	0.25	0.06
V_{16}: Size of past projects completed	1.00	0.00	1.00	0.85	1.00	0.29	0.09
V_{17}: National or local catchment	0.70	0.10	0.60	0.16	0.10	0.15	0.02
V_{18}: Failure to complete a contract	1.00	1.00	0.00	1.00	1.00	0.00	0.00
V_{19}: Contract overruns: time	1.00	0.10	0.90	0.51	0.50	0.35	0.12
V_{20}: Contract overruns: cost	1.00	0.10	0.90	0.45	0.40	0.34	0.11
V_{21}: Actual quality achieved	1.00	0.10	0.90	0.54	0.60	0.33	0.11
TENDERER EVALUATION VARIABLES							
V_{22}: Geographic experience	1.00	0.00	1.00	0.92	1.00	0.28	0.08
V_{23}: Experience similar construction	1.00	0.77	0.23	0.95	1.00	0.08	0.01
V_{24}: Plant resource	1.00	0.50	0.50	0.81	0.75	0.21	0.04
V_{25}: Key persons	1.00	0.50	0.50	0.87	1.00	0.17	0.03
V_{26}: Qualification - key persons	0.50	0.00	0.50	0.23	0.21	0.14	0.02
V_{27}: Workload	1.00	0.00	1.00	0.35	0.00	0.47	0.22
V_{28}: Prior relationship	1.00	0.00	1.00	0.75	0.90	0.30	0.09
V_{29}: Home office location	1.00	0.00	1.00	0.46	0.00	0.52	0.27

However, owners fared better than *key personnel.* Here, the low average values might indicate a need for greater investment in manager education / training but as intimated in the previous section, this appears a function of company profitability.

Variables 19, 20 and 21 each have a range of 0.9 confirming contractor disparity in the context of ability to achieve client time, cost and quality standards.

Observation of sample mean V scores (ie., the mean of all scores achieved for a given criterion, designated m hereafter) for prequalification criteria (V1 to V21), shows the five highest scoring variables in descending rank order to be;

i) *Failure to have completed a contract* (m =1.0), because the entire sample had indicated completion of all previous contracts.
ii) *Experience -type of projects completed* (m = 0.93), reflecting the inherent diversity of construction workload and that the sample did not contain specialist contractors (ie., limited specialist experience would achieve a low score in *this* evaluation because general, not specialist, firms are considered).
iii) *Experience -size of past projects completed* (m = 0.85), it seems contractors desirous to tender were seeking work of a similar size to that normally, or more specifically, previously undertaken.
iv) *Age of company* (m = 0.82), because the majority of firms had traded under the same company name for at least three years.
v) *Health and safety policy* (m = 0.74), here, a 'respectable' score is expected if only because of contractor's obligations to comply with The Health and Safety at Work Act 1974 (eg., formulation of an internal safety policy (HASWA 1974, section 2 (3)).

The three lowest mean scores achieved in descending order were;

i) *National or local catchment* (m = 0.16), reflecting local firms desirous to tender.

ii) *Qualification of key persons* (m = 0.21), which has previously been discussed.

iii) *Quality control policy* (m = 0.21), conformity to quality standards is still (in general terms) a voluntary undertaking and from these findings, appears to maintain a low level of importance for construction firms (cf. Griffith, 1990).

Concerning tenderer evaluation criteria (V22 to V29), a maximum score was achieved by at least one contractor within the sample, for every variable except V26: *qualification of key persons for the project*. This reinforces the contention made earlier pertaining to education and training of managers.

In general terms, mean values achieved amongst P2 criteria are higher than those emanating from prequalification. *Geographic experience* (m = 0.92) (within a 25 mile radius of the proposed project as evaluated here), again points toward local firms tendering. *Plant resource and key persons available* for the project (m = 0.81 and 0.87 respectively) might reflect the under-utilisation of these resources in light of poor construction demand of late. It appears that most firms have a respectable *previous working relationship* with the client (m = 0.75). Variable 27 was evaluated by comparison of contractors' vacant workload capacity in relation to financial resources required for the project. Based on these results there appears a tendency towards overtrading (m = 0.35).

Having investigated attribute scores in terms of absolute measures, further analyses were performed in terms of relative measures and, in terms of how representative these sample statistics are with respect to an infinite population of contractors. The measures used were: coefficient of variation, skewness and standard error of the mean.

Coefficient of variation

In observing dispersion, the prime disadvantage of the standard deviation is that it is expressed in natural units. We may convert this absolute measure of dispersion into a relative measure ie., the coefficient of variation. That is, express the standard deviation as a percentage of the mean via the formula; $cv = s / m \times 100 = \%$

where; cv = coefficient of variation, s = sample standard deviation and m = sample mean. The resultant may be expressed as a decimal or percentage. The latter is adopted within this discussion.

Skewness

Skewness measures the degree of asymmetry of the distribution, in this case, of attribute scores. In view that for a normal (symmetric) distribution the mean, median and mode all coincide, a skewness coefficient expresses this relationship (displacement of the median from the mean) in relative terms. This is achieved via the formula; Skewness $= 3(\text{mean} - \text{median}) / s$

where; skewness is a coefficient in the range -3 to 3, with zero representing symmetry. Positive skewness for example, means that a smaller portion of large positive scores tend to pull the mean towards the upper end of the scale (0.0 to 1.0) whilst negative skewness will have an opposite affect.

Standard error of the mean

Having calculated mean V scores amongst the sample we may explore how representative these statistics are, with respect to an infinite population of contractors. The standard error of the mean may be calculated from; $\sigma m = \sigma / \sqrt{n}$; where σm = standard error, σ = standard deviation of the population and n = sample size.

For samples where $n \geq 30$ then a normal distribution may be assumed (Freund et al, 1994) and hence, (because σ is not available) sample standard deviation (s) may be used. However, where $n < 30$ (as in this case) then a 'small sample' confidence interval may be calculated using the t-distribution (ibid), achieved via;

$[m - t_{\alpha/2} (s / \sqrt{n})] < \mu < [m + t_{\alpha/2} (s / \sqrt{n})]$ where; m = sample mean, $t_{\alpha/2}$ is the t-distribution area given α (the required degree of confidence), s = sample standard deviation and μ is population mean. Using the t distribution in this way offsets any asymmetry of the data. Therefore, m $\pm$ the confidence interval gives predicted population mean (μ) for the given confidence level. (Unless otherwise stated all statistical analyses within this thesis are based on a 95% confidence level). Tables 8.5. and 8.6. exhibit results of these three measures.

Table 8.5.
Further analysis of P1 attribute scores case studies A to C

	Coefficient of variation	Skewness	Confidence interval†	μ range
V1: Size of company	86%	-2.41	0.25	0.34 *to* 0.84
V2: Age of company	47%	-1.38	0.19	0.63 *to* 1.00
V3: Company image	51%	1.54	0.17	0.51 *to* 0.85
V4: Quality control policy	14%	2.03	0.15	0.06 *to* 0.36
V5: Health and safety policy	17%	0.92	0.06	0.68 *to* 0.80
V6: Litigation tendency	20%	-0.60	0.07	0.65 *to* 0.79
V7: Ratio analysis	60%	0.28	0.10	0.25 *to* 0.45
V8: Bank reference	92%	2.40	0.17	0.21 *to* 0.55
V9: Credit reference(s)	60%	-1.88	0.17	0.41 *to* 0.75
V10: Turnover history	82%	0.96	0.13	0.21 *to* 0.47
V11: Qualification -owners	64%	-0.88	0.13	0.29 *to* 0.55
V12: Qualification -key persons	88%	0.40	0.07	0.10 *to* 0.24
V13: Key persons yrs. with co'	100%	1.61	0.12	0.12 *to* 0.36
V14: Formal training regime'	52%	1.32	0.16	0.49 *to* 0.81
V15: Type -past projects completed	26%	-0.84	0.12	0.81 *to* 1.00
V16: Size -past projects completed	34%	-1.55	0.14	0.71 *to* 1.00
V17: National or local catchment	93%	1.20	0.07	0.09 *to* 0.23
V18: Failure to complete a contract	zero	-	zero	1.00
V19: Contract overruns: time	68%	0.08	0.17	0.34 *to* 0.68
V20: Contract overruns: cost	75%	0.44	0.16	0.29 *to* 0.61
V21: Actual quality achieved	61%	-0.54	0.16	0.38 *to* 0.70

†Determined from: 2.11 (s / 4.242) where 2.11 = $t_{0.025}$ (18 - 1 = 17 degrees of freedom) and 4.242 = $\sqrt{n}$ (n = 18).

Table 8.6.

Further analysis of P2 attribute scores case studies A to C

	Coefficient of variation	Skewness	Confidence interval†	μ range
V22: Geographic experience	30%	-0.85	0.16	0.76 *to* 1.00
V23: Experience similar construction	8%	-1.87	0.04	0.91 *to* 0.99
V24: Plant resource	26%	0.85	0.12	0.69 *to* 0.93
V25: Key persons	19%	-2.29	0.10	0.77 *to* 0.97
V26: Qualification - key persons	60%	0.42	0.08	0.15 *to* 0.31
V27: Workload	100%	2.23	0.28	0.07 *to* 0.63
V28: Prior relationship	40%	-1.50	0.18	0.57 *to* 0.93
V29: Home office location	100%	2.65	0.31	0.15 *to* 0.77

†Determined from: 2.179 (s / 3.605)
where 2.179 = $t_{0.025}$ (13 - 1 = 12 d.f.) and 3.605 = $\sqrt{n}$ (n = 13).

Caveat: results must be viewed in context -this sample alone cannot be representative of *all* contractors. Regarding sample size, as n becomes larger results become more precise. However, gains in precision are not proportional to increases in sample size. Indeed, a nine times larger sample is required to divide the standard error by three, or put another way, an increase in n from 50 to 20,000 reduces chance fluctuations only by a factor of 20 (Freund et al, 1994).

8.1.4.2. Discussion: 'good' and 'not so good' contractors

Having observed the WDC sample in its entirety, segregation was performed. Firstly, distinction was made between 'good' contractors and 'not so good' contractors. These classifications were established by asking the client to assign a value to each firm (based on past experience with them) in terms of each contractors' ability to achieve client time, cost and quality standards.

A scale of 1 to 10 was used where 1 = poor and 10 = excellent; for each of these three measures (ie., maximum possible score is 30). The mean of these three values yielding a score designated C_S. Hence: Σ scores awarded/3 = C_S where: $0.0 \leq C_S \leq 10$. The median value was used as a demarcation point. That is, where $C_S > 5.0$ then this was classified a 'good' contractor. Where $C_S \leq 5$ then the the firm was defined a 'not so good' (NSG) contractor. These distinctions yielded 11 (62%) 'good' and 7 (38%) 'not so good' clusters. Descriptive classification originated from the client who explained; "We do not deal with 'bad' contractors but it is a fact that some are better than others - hence 'good' and 'not so good'". Table 8.7. presents comparative statistics for these segregated sets. Table headings 1 to 4 show maximum / minimum value achieved, mean and standard deviation respectively (refer section 8.1.4.).

With respect to prequalification criteria (V1 to V21), between them, the 'good' contractors achieved a maximum score ≥ corresponding maximum scores for 'not so good' contractors, in the case of every criterion. This certainly indicates that the sets were correctly segregated and defined.

Headings 3 and 4 show that lowest score achieved amongst the sets for a given variable, was higher amongst 'not so good' contractors in all criteria except V16 *litigation tendency* and V15 *experience type of projects completed.* This firstly confirms greater variance amongst 'good' contractor scores. Secondly, it indicates that 'good' contractors seem less prone to litigation with clients (more agreeable in terms of settling claims etc?) and, as having had more extensive experience regarding types of project. The greater range in 'good' contractor scores is evidenced by comparison of the standard deviation between sets.

Mean attribute values, show scores obtained by 'good' contractors to be ≥ those obtained by 'not so good' contractors in 67 percent of criteria. The zero mean in V4 confirms that all of the NSG contractors were neither B.S. 5750 certified nor, intended to apply for such certification. Is this apathy on the part of NSG contractors with regard to achieving client satisfaction -quality of product?

Table 8.7.
Good contractors *vis-a-vis* not so good contractors: analysis of attribute scores

Variables	Max Value G	Max Value N	Min Value G	Min Value N	Mean Value G	Mean Value N	Standard Deviation G	Standard Deviation N
PREQUALIFICATION VARIABLES								
V_1: Size of company	**1.00**	1.00	**0.00**	0.00	**0.57**	0.67	**0.51**	0.58
V_2: Age of company	**1.00**	1.00	**0.00**	0.00	**0.93**	0.33	**0.27**	0.58
V_3: Company image	**1.00**	1.00	**0.00**	0.00	**0.71**	0.50	**0.32**	0.50
V_4: Quality control policy	**1.00**	0.00	**0.00**	0.00	**0.25**	0.00	**0.33**	0.00
V_5: Health and safety policy	**1.00**	0.80	**0.50**	0.70	**0.74**	0.73	**0.14**	0.06
V_6: Litigation tendency	**1.00**	0.60	**0.60**	0.50	**0.76**	0.53	**0.14**	0.06
V_7: Ratio analysis	**0.84**	0.50	**0.00**	0.33	**0.35**	0.39	**0.23**	0.10
V_8: Bank reference	**0.80**	0.40	**0.00**	0.00	**0.42**	0.17	**0.36**	0.21
V_9: Credit reference(s)	**1.00**	0.60	**0.10**	0.00	**0.62**	0.40	**0.35**	0.35
V_{10}: Turnover history	**0.75**	0.75	**0.00**	0.25	**0.29**	0.58	**0.26**	0.29
V_{11}: Qualification: company owners	**0.76**	0.71	**0.00**	0.36	**0.40**	0.49	**0.29**	0.19
V_{12}: Qualification of key persons	**0.47**	0.25	**0.00**	0.20	**0.16**	0.22	**0.17**	0.03
V_{13}: Key persons -yrs. with company	**0.70**	0.56	**0.00**	0.00	**0.26**	0.19	**0.25**	0.32
V_{14}: Formal training regime'	**1.00**	1.00	**0.00**	0.50	**0.61**	0.83	**0.35**	0.29
V_{15}: Type of past projects completed	**1.00**	1.00	**0.75**	0.00	**0.98**	0.67	**0.07**	0.58
V_{16}: Size of past projects completed	**1.00**	1.00	**0.00**	0.50	**0.89**	0.67	**0.29**	0.29
V_{17}: National or local catchment	**0.70**	0.10	**0.10**	0.10	**0.18**	0.10	**0.17**	0.00
V_{18}: Failure to complete a contract	**1.00**	1.00	**1.00**	1.00	**1.00**	1.00	**0.00**	0.00
V_{19}: Contract overruns: time	**1.00**	1.00	**0.10**	0.30	**0.51**	0.53	**0.35**	0.40
V_{20}: Contract overruns: cost	**1.00**	0.50	**0.10**	0.30	**0.47**	0.37	**0.37**	0.12
V_{21}: Actual quality achieved	**1.00**	0.60	**0.10**	0.30	**0.55**	0.50	**0.36**	0.17
TENDERER EVALUATION VARIABLES								
V_{22}: Geographic experience	**1.00**	1.00	**0.00**	1.00	0.90	1.00	**0.32**	0.00
V_{23}: Experience similar construction	**1.00**	1.00	**0.77**	0.88	0.94	0.96	**0.08**	0.07
V_{24}: Plant resource	**1.00**	1.00	**0.50**	0.50	**0.83**	0.75	**0.21**	0.25
V_{25}: Key persons	**1.00**	1.00	**0.50**	1.00	**0.82**	1.00	**0.18**	0.00
V_{26}: Qualification - key persons	**0.50**	0.25	**0.00**	0.10	**0.24**	0.19	**0.16**	0.08
V_{27}: Workload	**1.00**	1.00	**0.00**	0.00	0.35	0.33	**0.47**	0.58
V_{28}: Prior relationship	**1.00**	0.50	**0.00**	0.40	**0.83**	0.47	**0.30**	0.06
V_{29}: Home office location	**1.00**	1.00	**0.00**	1.00	0.30	1.00	**0.48**	0.00

Columns denoted G = 'good' contractors as perceived by client
Columns denoted N = 'not so good' contractors as perceived by client

In general terms, 'good' contractors exhibited the following features (corresponding NSG scores are shown in brackets for comparison);

-broad experience -type of projects	V15m = 0.98	(0.67)
-having traded for at least three years	V2 m = 0.93	(0.33)
-broad experience -size of projects	V16m = 0.89	(0.67)
-a good company image	V3 m = 0.71	(0.50).

'NSG' contractors (corresponding 'good' scores in brackets for comparison);

-were younger companies	V2 m = 0.33	(0.93)
-with poor bank references	V8 m = 0.17	(0.42)
- and poor credit references	V9 m = 0.40	(0.62).

In the context of P2 criteria (V22 to V29) there is less disparity between results for the two sets as was observed for the entire sample earlier (refer section 8.1.4.1). Taking an overall comparison between the sets in respect of *all* criteria, highest mean scores are split: 59 percent 'good' 38 percent 'not so good' and 3 percent equal. This intimates the 'good' set being just that ie., the model identified the better attributes of 'good' contractors, particularly, during prequalification. *Had the sample contained 'bad' contractors, we could reasonably assume that this contrast would be more pronounced.*

More detailed examination of the *mean* V scores yielded the statistics exhibited in Table 8.8. These show that the mean of all mean V scores for 'good' contractors, was higher when P1 and *all* V scores were considered. However, the converse was true for mean P2 scores. A t-test was performed to verify these results with the conclusion that P1 mean scores are significantly higher for the 'good' set but, that amongst P2 and *all*, judgment must be reserved.

Table 8.8.
Good / not so good contractors -investigation of mean V scores

	Good				*Not-so-good*			
	Mean	S.D.	Error	Variation	Mean	S.D.	Error	Variation
P1 means	0.55	0.26	0.06	47%	0.47	0.25	0.05	53%
P2 means	0.65	0.30	0.11	45%	0.71	0.34	0.12	47%
All means	0.58	0.27	0.05	46%	0.53	0.29	0.05	55%

Results of t-test between good / not so good means

	Required value of t	value of t	result
P1 means	1.725	1.98	significant difference between means
P2 means	1.895	-0.57	reserve judgment
All means	1.701	1.06	reserve judgment

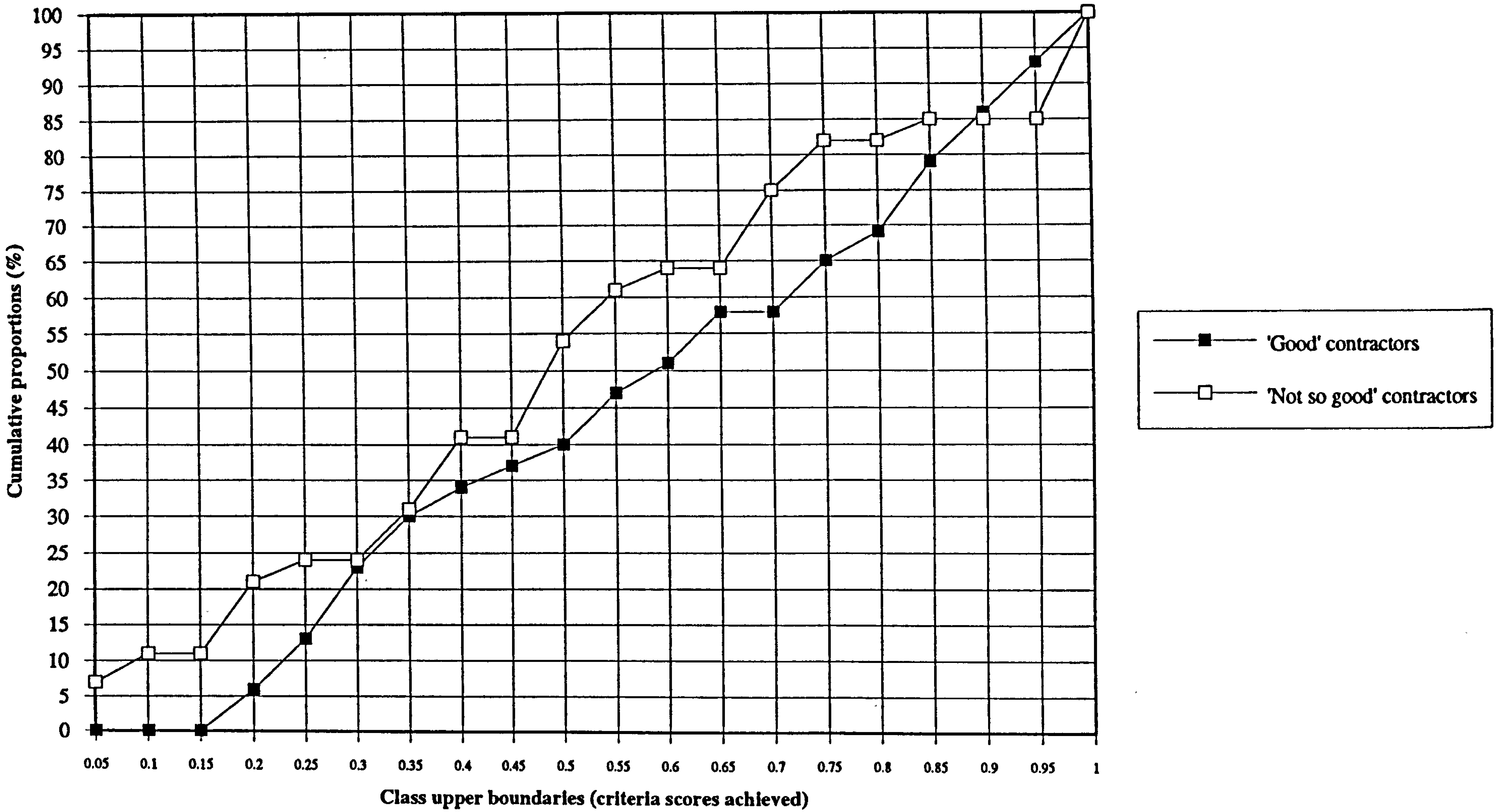
Required value of t is based on a paired sample, single tailed test ie., null hypothesis = mean amongst 'good' contractors is not greater than mean amongst not so good contractors with 95% significance.

The exercise is placed in context; by comparing the means in this way variance in the first group of data can be lost, increasing the probability of chance fluctuation. For this reason, more meaningful significance testing of raw V_i data, is conducted later in this Chapter.

Finally, with respect to the 'good' / 'not so good' clusters, graphical distinction was sought using cumulative proportion analysis. To achieve this, the V scale (ie., 0.0 to 1.0) was decomposed into 20 classes with the class boundaries: 0.0 to 0.05, 0.06 to 0.10,..., 0.96 to 1.0. Mean variable scores achieved in respect of *all* 29 attributes, for both sets of contractors, were recorded within their relevant classes. This tally was then converted to a cumulative percentage. That is, the percentage of mean variable scores, falling within given class boundaries, for each set. The plotting of these results facilitated the cumulative proportion graph presented in Figure 8.6.

'Good' contractors exhibit a greater proportion of mean scores in the classes ≥ 0.90,

Figure 8.6. Cumulative proportion graph: mean V scores for good / NSG contractors, all variables



with no mean scores in the classes ≤ 0.15. Alternatively, 'not so good' contractors exhibit a greater proportion of lower attribute scores, particularly below the boundary 0.3 and a reduced proportion of higher variable scores, particularly above the boundary 0.9.

'Not so good' contractors display a higher proportion of mean scores about the mid range eg., for $V_i = 0.5$ then 'not so good' = 54 percentile, 'good' = 40 percentile. Indeed, the difference in sets is pronounced by observation of the lower (Q_1) / upper (Q_3) quartiles and median;

Good contractors	$Q_1 = 0.32$	$M = 0.83$	$Q_3 = 0.83$
'Not so good' contractors	$Q_1 = 0.31$	$M = 0.70$	$Q_3 = 0.70$.

8.1.4.3. Discussion: highest bidders vis-a-vis lowest bidders

Comparison was performed amongst the WDC sample by analysis of mean attribute scores achieved for the three highest and lowest bidders. Table 8.9. presents statistics applicable to these two sets.

High bidders achieved a higher V score in 42% of P1 variables with low bidders being higher 38% of the time. The remaining 20% of mean P1 V scores were equally scored.

Regarding P2 attribute scores, in a similar vein to 'good' and 'not so good' earlier there is less disparity between the maximum values achieved for both sets with a greater degree of variance amongst higher bidders.

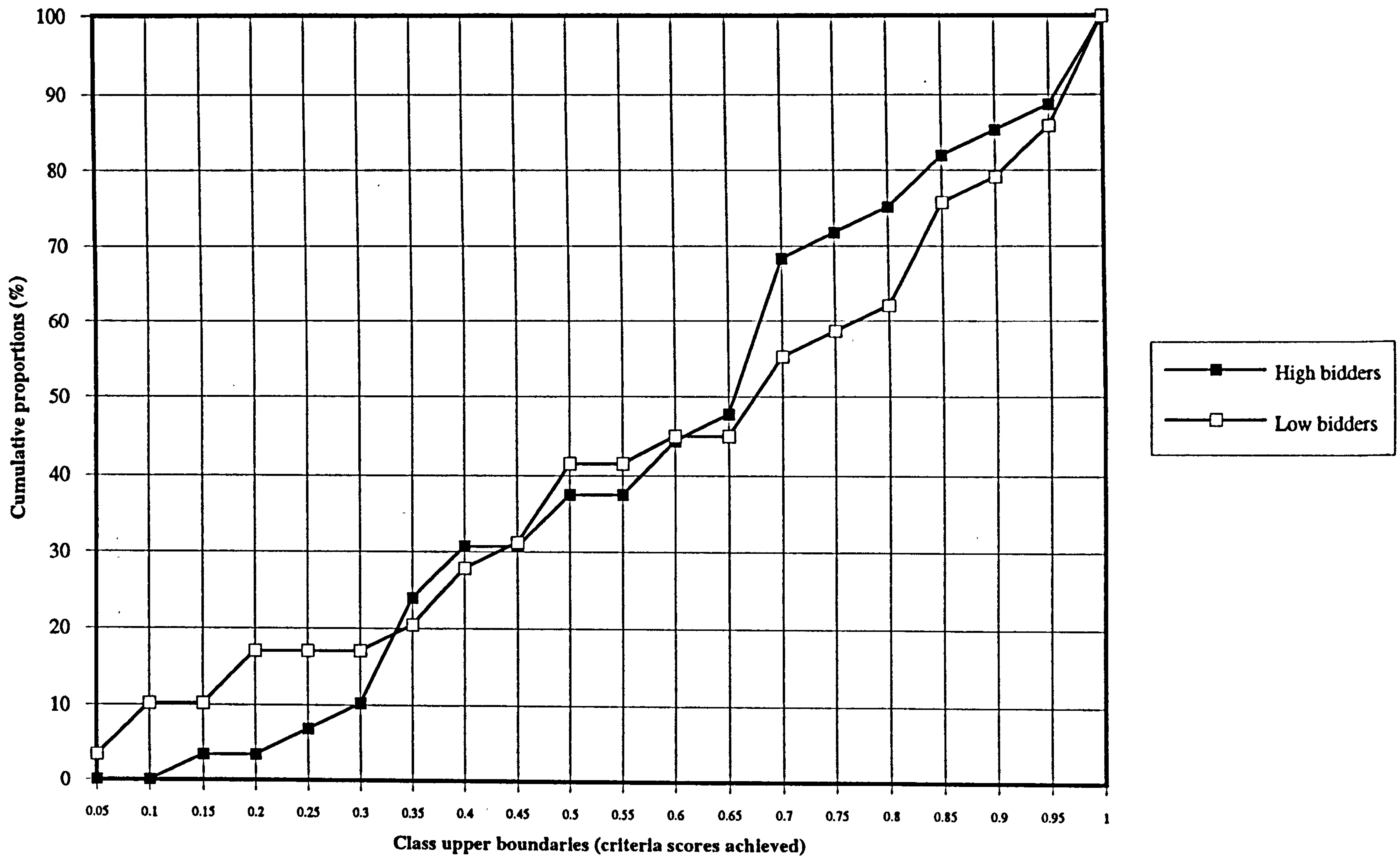
A cumulative proportion analysis similar to that described earlier, was also performed upon these two sets with the resulting ogives (highest / lowest bidders) presented in Figure 8.7.

Table 8.9.
Highest bidders *vis-a-vis* lowest bidders: analysis of attribute scores

Variables	Max Value H	Max Value L	Min Value H	Min Value L	Mean Value H	Mean Value L	Standard Deviation H	Standard Deviation L
PREQUALIFICATION VARIABLES								
V_1: Size of company	**1.00**	1.00	**1.00**	0.00	**1.00**	0.67	**0.00**	0.58
V_2: Age of company	**1.00**	1.00	**0.00**	1.00	**0.33**	1.00	**0.58**	0.00
V_3: Company image	**0.50**	1.00	**0.00**	0.50	**0.33**	0.83	**0.29**	0.29
V_4: Quality control policy	**0.50**	0.50	**0.00**	0.00	**0.33**	0.17	**0.29**	0.29
V_5: Health and safety policy	**0.90**	0.90	**0.70**	0.60	**0.77**	0.70	**0.12**	0.17
V_6: Litigation tendency	**0.90**	1.00	**0.50**	0.60	**0.67**	0.80	**0.21**	0.20
V_7: Ratio analysis	**0.33**	0.50	**0.17**	0.33	**0.28**	0.44	**0.10**	0.10
V_8: Bank reference	**0.80**	0.90	**0.10**	0.10	**0.57**	0.47	**0.40**	0.35
V_9: Credit reference(s)	**0.80**	0.90	**0.60**	0.50	**0.73**	0.73	**0.12**	0.12
V_{10}: Turnover history	**0.75**	0.50	**0.25**	0.00	**0.50**	0.33	**0.25**	0.29
V_{11}: Qualification: company owners	**0.71**	0.70	**0.51**	0.00	**0.64**	0.40	**0.11**	0.36
V_{12}: Qualification of key persons	**0.47**	0.15	**0.20**	0.00	**0.34**	0.07	**0.14**	0.08
V_{13}: Key persons -yrs. with company	**0.56**	0.70	**0.00**	0.50	**0.22**	0.60	**0.30**	0.10
V_{14}: Formal training regime'	**1.00**	1.00	**0.50**	0.00	**0.67**	0.67	**0.29**	0.58
V_{15}: Type of past projects completed	**1.00**	1.00	**0.00**	0.75	**0.67**	0.92	**0.58**	0.14
V_{16}: Size of past projects completed	**1.00**	1.00	**0.50**	0.50	**0.83**	0.83	**0.29**	0.29
V_{17}: National or local catchment	**0.70**	0.10	**0.10**	0.10	**0.37**	0.10	**0.31**	0.00
V_{18}: Failure to complete a contract	**1.00**	1.00	**1.00**	1.00	**1.00**	1.00	**0.00**	0.00
V_{19}: Contract overruns: time	**1.00**	0.50	**0.70**	0.50	**0.83**	0.50	**0.15**	0.00
V_{20}: Contract overruns: cost	**0.80**	1.00	**0.40**	0.70	**0.57**	0.83	**0.21**	0.15
V_{21}: Actual quality achieved	**0.80**	0.90	**0.60**	0.80	**0.67**	0.83	**0.12**	0.06
TENDERER EVALUATION VARIABLES								
V_{22}: Geographic experience	**1.00**	1.00	**0.00**	1.00	**0.67**	1.00	**0.58**	0.00
V_{23}: Experience similar construction	**1.00**	1.00	**0.77**	1.00	**0.88**	1.00	**0.12**	0.00
V_{24}: Plant resource	**1.00**	1.00	**0.75**	1.00	**0.92**	1.00	**0.14**	0.00
V_{25}: Key persons	**1.00**	1.00	**1.00**	0.84	**1.00**	0.92	**0.00**	0.12
V_{26}: Qualification - key persons	**0.19**	0.31	**0.06**	0.00	**0.12**	0.16	**0.06**	0.22
V_{27}: Workload	**1.00**	0.00	**0.00**	0.00	**0.67**	0.00	**0.58**	0.00
V_{28}: Prior relationship	**0.90**	0.90	**0.00**	0.90	**0.47**	0.90	**0.45**	0.00
V_{29}: Home office location	**1.00**	1.00	**0.00**	0.00	**0.33**	0.50	**0.58**	0.71

Columns denoted H = three highest bidders
Columns denoted L = three lowest bidders

Figure 8.7. Cumulative proportion graph: mean variable scores for high and low bidders



The comparison confirms that higher bidders exhibit a greater proportion of higher attribute scores. Low bidders show the exact opposite characteristics. Overall, high bidders exhibited the following positive attributes (low bidders in brackets for comparison);

-adequate resources	V1 m = 1.00	(0.67)
-adequate H&S policy	V5 m = 0.77	(0.70)
-minimum time overruns	V19 m = 0.83	(0.50)
-adequate spare workload	V27 m = 0.67	(0.00).

Low bidders performed much better in terms of;

-age	V2 m = 1.00	(0.33)
-image	V3 m = 0.83	(0.33)
-geographic experience	V22 m = 1.00	(0.67).

8.1.4.4. Summary analysis of attribute scores

Mean attribute scores achieved amongst all subsets discussed so far, are presented in Table 8.10. First point of note is that 'good' contractors achieve a greater *proportion* of higher attribute scores *vis-a-vis* NSG contractors, during P1 analysis. The mean of mean attribute scores confirms this (P1 'good' = 0.55, P1 NSG = 0.50). Highest mean scores are equally split between these sets in P2 analysis but, the overall mean of means shows that where NSG contractors did score highest, then the relative difference was more pronounced.

A similar situation pertains to low bidders. High bidders achieved attribute scores ≥ attribute scores of low bidders 62% of the time. The corresponding statistic for low bidders is 57% ie., high bidders score better more often. However, there is greater difference in actual scores achieved: high bidders scored an average of 0.18 over and above low bidders, amongst those criteria that high bidders scored best.

Table 8.10.
Summary analysis of all mean V scores, case studies A to C

	All	Good	NSG	High	Low
PREQUALIFICATION VARIABLES					
V_1: Size of company	0.59	0.57	0.67	1.00	0.67
V_2: Age of company	0.82	0.93	0.33	0.33	1.00
V_3: Company image	0.68	0.71	0.50	0.33	0.83
V_4: Quality control policy	0.21	0.25	0.00	0.33	0.17
V_5: Health and safety policy	0.74	0.74	0.73	0.77	0.70
V_6: Litigation tendency	0.72	0.76	0.53	0.67	0.80
V_7: Ratio analysis	0.35	0.35	0.39	0.28	0.44
V_8: Bank reference	0.38	0.42	0.17	0.57	0.47
V_9: Credit reference(s)	0.58	0.62	0.40	0.73	0.73
V_{10}: Turnover history	0.34	0.29	0.58	0.50	0.33
V_{11}: Qualification: company owners	0.42	0.40	0.49	0.64	0.40
V_{12}: Qualification of key persons	0.17	0.16	0.22	0.34	0.07
V_{13}: Key persons -yrs. with company	0.24	0.26	0.19	0.22	0.60
V_{14}: Formal training regime'	0.65	0.61	0.83	0.67	0.67
V_{15}: Type of past projects completed	0.93	0.98	0.67	0.67	0.92
V_{16}: Size of past projects completed	0.85	0.89	0.67	0.83	0.83
V_{17}: National or local catchment	0.16	0.18	0.10	0.37	0.10
V_{18}: Failure to complete a contract	1.00	1.00	1.00	1.00	1.00
V_{19}: Contract overruns: time	0.51	0.51	0.53	0.83	0.50
V_{20}: Contract overruns: cost	0.45	0.47	0.37	0.57	0.83
V_{21}: Actual quality achieved	0.54	0.55	0.50	0.67	0.83
mean:	**0.53**	**0.55**	**0.50**	**0.58**	**0.61**
TENDERER EVALUATION VARIABLES					
V_{22}: Geographic experience	0.92	0.90	1.00	0.67	1.00
V_{23}: Experience similar construction	0.95	0.94	0.96	0.88	1.00
V_{24}: Plant resource	0.81	0.83	0.73	0.92	1.00
V_{25}: Key persons	0.87	0.82	1.00	1.00	0.92
V_{26}: Qualification - key persons	0.23	0.24	0.19	0.12	0.16
V_{27}: Workload	0.35	0.35	0.33	0.67	0.00
V_{28}: Prior relationship	0.75	0.83	0.47	0.47	0.90
V_{29}: Home office location	0.56	0.30	1.00	0.33	0.50
mean:	**0.68**	**0.65**	**0.71**	**0.63**	**0.68**

For low bidders the mean difference amongst higher scoring variables is 0.35. In conclusion, this means that higher bidders scored better *more of the time*, but, low bidders achieved a more marked difference in those higher scores achieved.

8.1.5. Statistical analysis of the model outputs

Having paid detailed attention to attribute scores achieved amongst the sample, there now follows analysis of actual model outputs. That is, the prequalification and tenderer factor scores (*P*FS & *T*FS respectively) along with P1, P2 and P3 outputs. Strength of association, central tendency and dispersion amongst these components together with comparison to C_S for each contractor (refer 8.1.4.2.) were investigated.

8.1.5.1. Qualitative comparison: model output and client experience

Prior to quantitative analyses of model output, firstly a comparison is made between the salient aspects of the contractors as highlighted by the model during P1 analysis and, the clients past experience of the firms.

Case study B is highlighted. The project prequalified eight contractors -this number being ample to achieve such qualitative comparison. It is pointed out that the two groups of statements which follow for each contractor (ie., P1 then Client) were compiled independently, that is, without either party liaising with the other at the time.

Contractor 1

P1 rank 1st: Organisational structure / workload capacity adequate. Liquidity good but current liabilities high vis-a-vis net assets. Turnover and R.O.C.E. show contraction. Management resource satisfactory. A regional, mature company able to meet client time and quality standards but, expected to be at a cost (£).

Client rank 3rd: Established contractor, not claims conscious, excellent quality of work, good office / site management.

Comment: Here the model awarded the highest P1 score of the set, so did the client rank the firm 3rd because of the potential extra cost of employing what was identified as the best contractor? Indeed, this contractor was awarded the lowest past performance (cost) rating by the client, of all contractors amongst this case study.

Contractor 2

P1 rank 3rd: Organisational structure satisfactory, adequate workload capacity. Financially, two of the three accounting ratios observed were below respective critical limits, the other merely border line. A decline in R.O.C.E. and turnover was also evident. Management resource satisfactory. An experienced company, having a large catchment and good past performance rating.

Client rank joint 1st: Excellent resources and management, very keen to work.

Comment: The model identified contractor 2 as 'good' but most concern is for financial stability. 'Keen to work' might indicate cash flow problems but this seems contradictory in that the firm later submitted the highest tender (55% above lowest tender and 29% above the mean tender figure for this contract).

Contractor 3

P1 rank 5th: Organisational structure satisfactory but lower workload capacity than the two previous firms. Financial aspects as per contractor 2. Management resource low with no formal training regime in existence. Past experience / performance satisfactory only.

Client rank 4th: Old fashioned management, would suspect claims (£) to be forthcoming, but no problems with past performance or quality.

Comment: Smaller company in resource terms, ditto to the last financially. The client confirmed that contractor claims may increase the project outturn cost. Both the model and client concern over cost, was justified in part by this contractor later submitting the highest-but-one bid (42% above lowest tender and 19% above mean tender figure).

Contractor 4

P1 rank 4th: Organisational structure satisfactory, workload capacity borderline. No B.S.5750 quality control certification or intent to apply for such. Financially; liquidity good but NA/CL poor along with declining R.O.C.E. and turnover. Further, this contractors' financial indebtedness to its holding company causes concern. Local catchment only.

Client rank joint 1st: Excellent management involvement, good prior relationship, low claims consciousness, strives for high quality.

Comment: Overall, not a 'bad' contractor but only 'good' so long as it's parent company continues to support it. The latter is a debtor to the contractor for approximately 25% of it's turnover! Perhaps the client offset this risk factor in favour of good previous working relationships?

Contractor 5

P1 rank 6th. Workload capacity questionable and a low fixed asset base vis-a-vis liabilities. Liquidity borderline and management resource poor. Past performance scores are good but greatest concern is with financial stability.

Client rank joint 2nd: Excellent workmanship, would expect claims to arise, good prior relationship, but concerns for contract overrun -time and cost.

Comment: Again, contractor is financially questionable but apparently overlooked by the client in favour of good previous relationships. This contractor later submitted the lowest bid. Caveat: association between low bids / poor liquidity / cashflow problems have been highlighted in earlier Chapters. Concern for financial stability -particularly liquidity, is exacerbated by lowest tender.

Contractor 6

P1 rank 2nd. Workload capacity adequate, organisational aspects satisfactory and financially, scored the best of all eight firms. A reasonable balance exists between past time, cost and quality performance. A higher score achieved in management resource would have resulted in this contractor achieving the best P1 score for this project.

Client rank joint 3rd: Large and established firm, excellent resources, high profile, good quality record.

Comment: Financially the most stable as confirmed by clients' reference to resources, so why only ranked 3rd by latter?

Contractors 7 and 8

P1 ranks: These firms are not in the running according to the model, they achieved the lowest-but-one and lowest P1 scores respectively. These results correlated perfectly with C_S ranks ie., last-but-one and last also.

8.1.5.2. Commentary on qualitative comparison

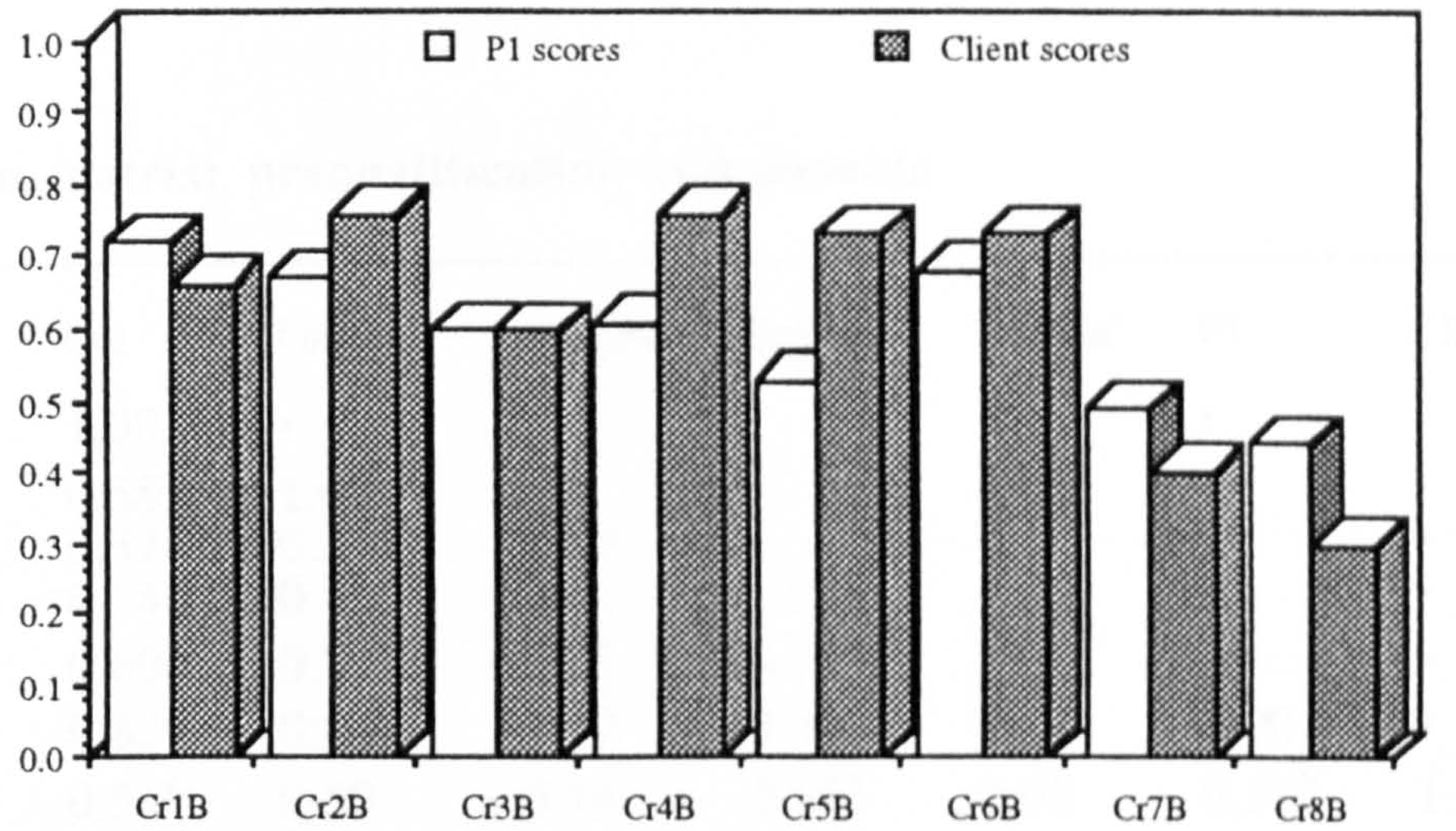
It is apparent that the model performed an extensive evaluation of each contractor and was able to summarise the dominant characteristics of each firm. In particular, it is encouraging that financial concerns were highlighted. The latter need to be flagged up particularly, in respect of contractors who subsequently submit a low bid which may be purely to maintain crucial cashflow -refer contractor 5 (caveat: the low bid may achieve award of contract but will the poor / none existent element of profit in such bids contribute further to the firms demise, or ultimate failure?).

Highest P1 score went to contractor 1 but this firm only achieved third rank based on C_S. On the face of it this is illogical in that the client said: "established, not claims conscious, excellent quality and good management" but encouraging, in that the model identified these *positive* characteristics. Second highest P1 score was ranked third by the client, this similarity in rank order reassuring in terms of model integrity.

At the opposite end of the scale, there was perfect agreement between P1 and C_S with contractors 7 and 8 being scored / ranked last and last-but-one by both model and client.

In summary, we can attribute differences in score and rank primarily due to the fact that model output was a function of each contractors' standing at the time of evaluation (fundamental philosophy behind P1 -refer Chapter 5), whilst C_S was based on *previous* working relationships. The latter approach is intrinsic within current selection practice. Graphical representation of P1 / client scores may be compared in Figure 8.8.

Figure 8.8.
Graphical comparison of P1 and C_S



Client score based on past experience (0.1 = poor, 1.0 = excellent) -refer to text.

8.1.6. Correlational investigation of FS, P scores and C_S

Correlation matrices were produced using the Pearson Product Moment test, this test being used for the same reasons outlined in section 8.1.3. Table 8.11. is a matrix showing correlation coefficients (r) amongst P1 components for all contractors prequalified. There is strong association between P1 score and ***P***FS: *financial* *stability* (r = 0.89), *contractor (past) performance* (r = 0.87) and *contractors organisation* (r = 0.82).

The lower degree of association between the remaining *PFS* (*management resource r = 0.49* and *contractor experience r = 0.36*) indicates that benefit may accrue from performing a stepwise regression analysis of all *PFS* upon P1 score, when a larger sample of data are available. That is, if P1 can be predicted with statistical significance using only three *PFS* then this would rationalise the overall process further. Section 8.6. later expands on this point.

Table 8.11.
Correlation matrix: prequalification components

	Org	Finance	Mangmnt	Expmce	Perform'	P1	Client
Organisation	1.00	*	*	*	*	*	*
Financial	0.58^{a}	1.00	*	*	*	*	*
Management	0.37	0.39	1.00	*	*	*	*
Experience	0.34	0.28	- 0.44	1.00	*	*	*
Performance	0.60^{a}	0.79^{b}	0.43	0.13	1.00	*	*
P1 score	0.82^{b}	0.89^{b}	0.49	0.36	0.87^{a}	1.00	*
Client	0.56^{a}	0.50	- 0.13	0.59^{a}	0.46	0.57^{b}	1.00

a = *1 tailed significance: 0.01*
b = *1 tailed significance: 0.001*

There is strong association between C_s and the factors; *contractor experience* (r = 0.59) and Cs / *contractors organisation* (r = 0.56), both significant at the 0.01 level. This may indicate C_s being a function of client perception regarding contractor ability in relation to criteria attributable to these two factors. The significant association between P1 score and C_s (r = 0.57, signif. 0.001) is an excellent result. This shows strong correlation between the conclusion of P1 analysis ie., P1 score and client perception of contractor performance ability. That it was not stronger is a function of the respective methods of achieving C_S and P1 scores, discussed in the previous section.

Finally, r = 0.58 between *financial stability / contractors organisation*, confirms the earlier findings of this work ie., that contractors with adequate turnover, R.O.C.E. and sensible gearing, (a high score in *PFS financial stability*) are more likely to apportion adequate resources towards; health & safety, quality control and, have less tendency to litigate (criteria attributable to *contractors organisation*).

From Table 8.12.the strong correlation between P2 score and *TFS*: *project specific* (r = 0.72), *other specific* ($r = 0.76$) confirms that P2 is a balanced function of both.

Table 8.12.
Correlation matrix: *TFS* / P2 / P3 components

	Project specific	Other specific	Bid score	P2 score	P3 score
Project	1.00	*	*	*	*
Other	0.11	1.00	*	*	*
Bid	- 0.18	- 0.00	1.00	*	*
P2	0.72[b]	0.76[a]	- 0.10	1.00	*
P3	0.05	0.25	0.94[b]	0.22	1.00

a = *1 tailed significance: 0.01*
b = *1 tailed significance: 0.001*

A coefficient of $r = 0.94$ significant at the .0001 level for BS / P3 score, confirms the strong influence of BS upon P3 using the current 60% cost / 40% P2 ratio. Influence of these coefficients upon P3 is later investigated under "The sensitivity of P3 score".

8.1.6.1 Further analysis of factor scores

The following analyses segregate the sample into sub-groups. "All contractors" refers to the eighteen contractors in a P1 context and the thirteen WDC tenderers in a P2 context. Good and NSG are as explained earlier.

The mean of prequalification factor scores (*P*FS) achieved, amongst all sub-groups are shown in Table 8.13. along with standard deviation.

Table 8.13.
Prequalification factor scores (*P*FS) central tendency and variability

	Factors				
	Contractor organisation	*Financial stability*	*Management resource*	*Past experience*	*Past performance*
Mean *P*FS scores					
All	0.62	0.41	0.40	0.66	0.64
GOOD	0.71	0.52	0.42	0.72	0.77
N.S.G.	0.49	0.25	0.37	0.57	0.76
S. Deviation					
All	0.16	0.20	0.14	0.17	0.22
GOOD	0.15	0.13	0.14	0.11	0.16
N.S.G.	0.05	0.18	0.16	0.20	0.17

For each sub-group *management resource* and *financial stability* scored the lowest. The former poor and latter worrying characteristics of contractors, confirming earlier observations in this Chapter. The higher mean *P*FS's amongst the 'good' set of contractors (higher *P*FS in every case) confirms the models' integrity ie., PFS_m for 'good' > PFS_m for 'all' and, PFS_m for 'good' > PFS_m for 'NSG' (m = all prequalification factors).

Further, it is seen from the standard deviation amongst the 'good' set that their better scores are more concentrated about the mean value. That is, they were more consistently 'good'. A t-test confirmed these differences between all / 'good' significant at the 99% level and, between 'good' / NSG significant at the 95% level.

Table 8.14. shows a similar matrix of statistics for mean *TFS* scores.

Table 8.14.
Tenderer factor scores (*TFS*), central tendency and variability

Factor	Mean *TFS* value			Standard deviation		
	All	*Good*	*NSG*	*All*	*Good*	*NSG*
Project specific criteria	0.578	0.582	0.569	0.071	0.082	0.044
Other specific criteria	0.362	0.360	0.368	0.094	0.098	0.096

Generally, tenderers scored higher in *project specific* criteria with lower scores in *other specific* criteria. The latter was primarily a function of firms scoring low in terms of spare workload capacity. Capacity evaluation took into account all projects in hand along with those to be commenced during the period of the project being tendered for. A clear tendency towards overtrading was observed (being essentially a function of reduced assets combined with increased liabilities, as opposed to a drastic upturn in workload) and reflects the difficulties that contractors have suffered of late.

Good contractors achieved mean *TFS* higher than NSG contractors under *project specific* criteria but, there was little distinction to be made between the sets for *other specific* criteria.

8.1.6.2. Further analysis of P scores

Table 8.15. exhibits the maximum, minimum, mean and standard deviation of all P scores achieved amongst the WDC sample.

Table 8.15.
Analysis of P score output: all contractors and by sub-groups

	P1 score				P2 score				P3 score			
SET	Max	Min	Mean	S.D	Max	Min	Mean	S.D	Max	Min	Mean	S.D
ALL	**0.72**	**0.34**	**0.54**	**0.12**	**0.61**	**0.38**	**0.48**	**0.05**	**0.80**	**0.56**	**0.72**	**0.07**
GOOD	0.72	0.40	0.62	0.09	0.61	0.38	0.48	0.07	0.80	0.56	0.71	0.08
N.S.G.	0.49	0.34	0.42	0.06	0.50	0.46	0.47	0.02	0.77	0.73	0.74	0.01

Again, model integrity is confirmed in that *maximum* P score achieved amongst the sample, was by a 'good' contractor in every case and, that maximum P score for 'good' contractors > maximum P scores achieved for NSG contractors.

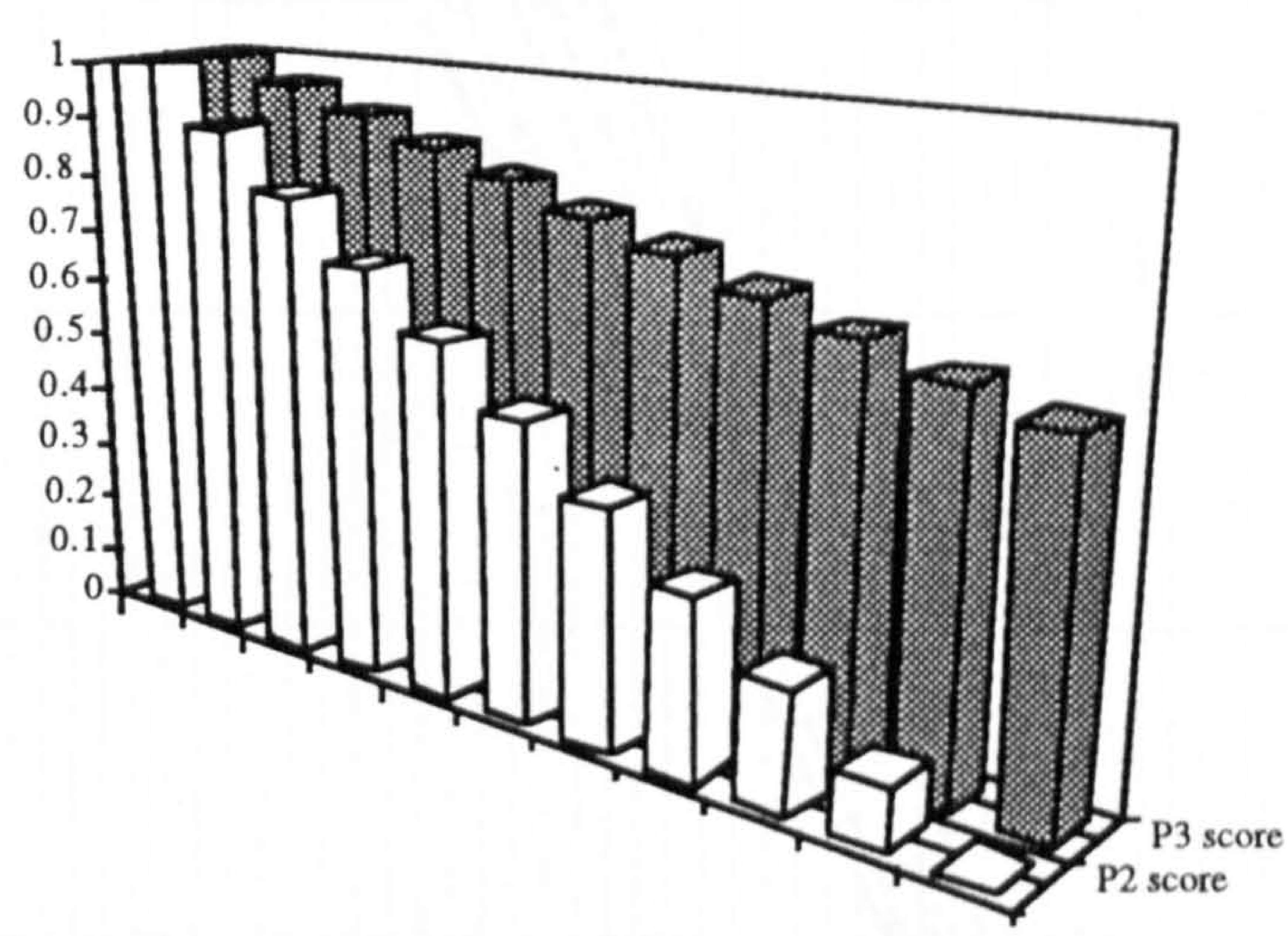
Minimum P score achieved was higher for 'good' contractors than NSG during prequalification, indicating that 'good' contractors scores' are grouped about a point higher on the scoring scale than NSG contractors. This was not so for P2 and P3 scores as confirmed by the standard deviation in each case. Encouraging also was that Mean P scores for 'good' ≥ 'all' *and* NSG during P1 analysis, 'good' ≥ 'all' *and* NSG during P2 analysis. Surprisingly, mean values for 'good' ≤ 'all' and NSG during P3 analysis. Closer investigation of this apparent rogue result uncovered one extreme low P3 value within the 'good' set and subsequent calculation of the median (to counteract this extreme value) yielded; 'good' contractors a median of 0.75 and 'not so good' a median of 0.74.

8.2. THE SENSITIVITY OF P3 SCORE

Referral to Table 8.12. will remind the reader that a correlation coefficient of 0.94 with almost absolute significance, existed between bid score (BS) and P3 score. In that instance P3 was the product of 0.6BS + 0.4P2 score. Clearly, this strong association called for investigation of P3 sensitivity in relation to changes in these coefficients.

Figure 8.9. graphically shows the sensitivity of P3 using these same coefficients for the entire range of P2 score from zero to 1.0 assuming a BS of 1.0 (ie., the lowest bidder). Note the linearity between P2 / P3 and that the scale is interval.

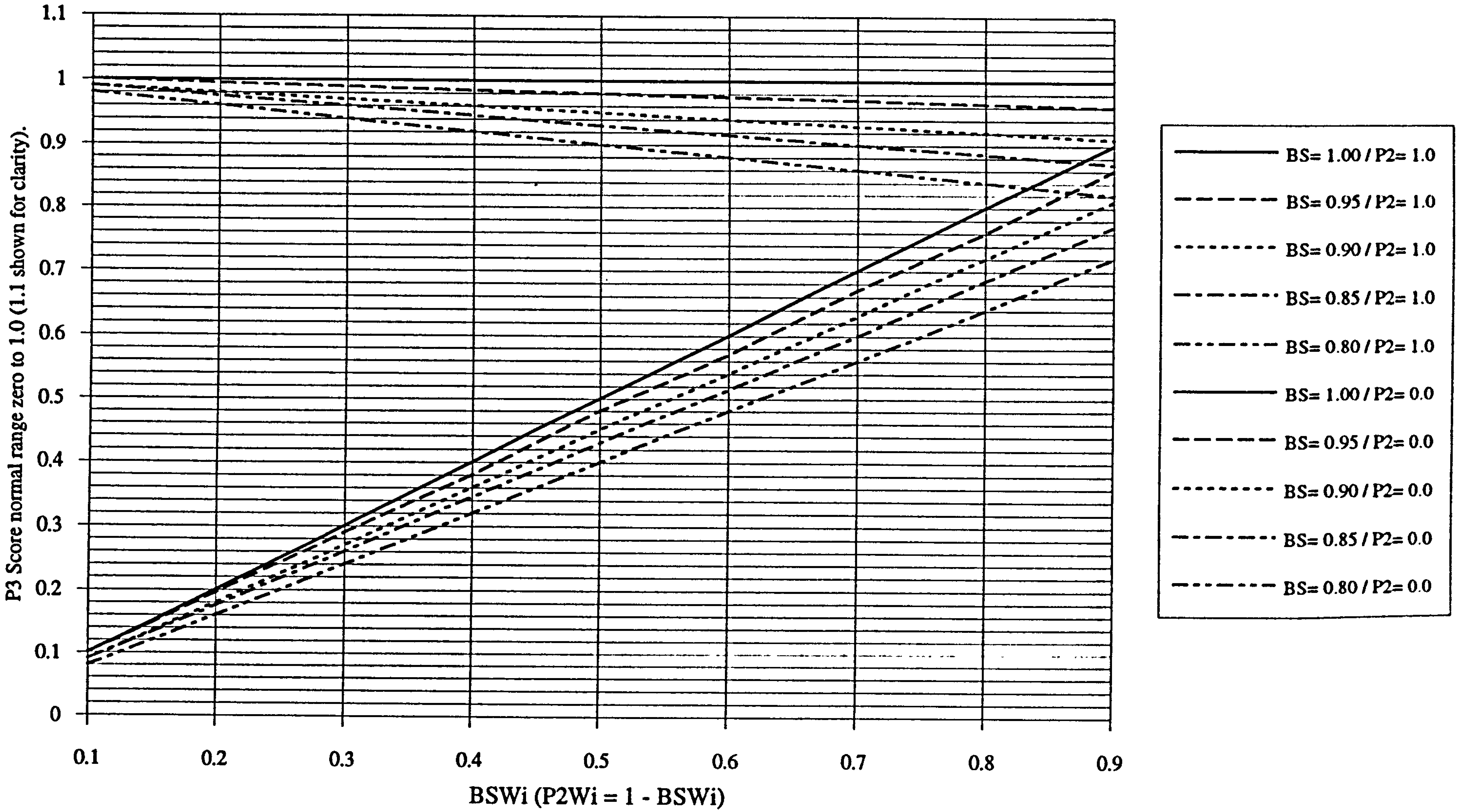
Figure 8.9.
Sensitivity of P3 given BS = 1.0, BSW_i = 0.6, $P2W_i$ = 0.4



Decreasing P2 score shown from a maximum score of 1.0 to a minimum score of zero in increments of 0.1. Range of P3: respective linear decrease from 1.0 to 0.6.

Figure 8.10. further investigates P3 score sensitivity for the range of BS's: 0.8 to 1.0, in increments of 0.5.

Figure 8.10. Graphical sensitivity of P3 score given all ramifications of Bid Score, P2 score, BSWi and P2Wi



Descriptions in legend correlate with respective vertical position of graph lines. Example: when BSWi = 0.6 then P3 ≥ 0.52 and ≤ 0.92 for a contractor with BS = 0.85. Refer to text for full explanation.

This range is ample because, by virtue of the composition of BS (ie., BS_j = lowest tender / contractor $_j$'s tender) then BS = 0.8 represents a deviation in tender sum of 25% from lowest bid. Greater variance begs the question: is this a 'suicidally low' or 'misconceived' bid? -see Merna & Smith (1990).

Because of the aforementioned linearity, Figure 8.10. need only give extreme values for each BS scenario. That is, for each of the five BS's above then P2 = 0.0 (5 lowest lines on graph) and P2 = 1.0 (5 uppermost lines on graph) are shown.

It can be seen that greatest P3 range is offered when $BSW_i = 0.1$ (ie., P3 = 0.08 for a BS of 0.8 and P3 = 1.0 for a BS of 1.0). Smallest P3 range is offered where BSW_i = 0.9 (ie., P3 = 0.72 to 1.0). However, these values are the extremes -optimum coefficients must lie somewhere between. We may therefore observe the effects of variation in these coefficients upon P3 and, the resulting strength of association between P3 and C_s for each contractor.

Table 8.16. shows P3 scores for all contractors invited to tender. P3 score has been computed for each firm assuming: BSW_i = 0.3, 0.4,...., 0.7. Because $BSW_i + P2W_i$ = 1.0 the corresponding $P2W_i$ are 0.7, 0.6,...,0.3.

For each of these scenarios, the resulting P3 scores were transformed from interval, to ordinal data ie., ranked from high to low. Respective C_s were also ranked. Where there were ties in rank, each of the tied observations were assigned the mean of the ranks they occupied.

This approach facilitated the measurement of correlation between any of the sets (scenarios), using the Spearman's Rank-correlation test (Meddis, 1984). This test of association is also particularly suited to samples of a smaller size such as this. Sets of ranks were checked using the formula; $R_n = \{N(N+1) / 2\}$ where: N is the total number of observations ranked and R_n is the total sum of ranks (Meddis, 1984).

Table 8.16.
P3 scores / C_s and ranks: tenderers

	Scenarios											
	BSWi = 0.3		BSWi = 0.4		BSWi = 0.5		BSWi = 0.6		BSWi = 0.7		Client	
	P3	Rank	P3	Rank	P3	Rank	P3	Rank	P3	Rank	Cs	Rank
Cr1	0.627	4	0.651	8	0.675	10	0.700	10	0.724	10	6.67	7.5
Cr2	0.512	11	0.531	11	0.549	12	0.568	12	0.587	12	7.67	2
Cr3	0.499	12	0.527	12	0.556	11	0.585	11	0.613	11	6.00	9
Cr4	0.634	3	0.678	3	0.721	5	0.765	5	0.808	5	7.67	2
Cr5	0.657	2	0.706	1	0.755	1	0.804	1	0.853	1	7.3	5
Cr6	0.677	1	0.700	2	0.722	3.5	0.744	7	0.766	9	7.3	5
Cr7	0.617	7	0.668	5	0.719	6	0.770	4	0.821	4	4.0	10
Cr8	0.598	9	0.664	9	0.690	8	0.736	8	0.782	7	3.0	11.5
Cr9	0.564	10	0.625	10	0.685	9	0.746	6	0.806	6	7.3	5
Cr10	0.610	8	0.666	6	0.722	3.5	0.777	3	0.833	3	6.67	7.5
Cr11	0.620	6	0.658	7	0.695	7	0.732	9	0.769	8	3.0	11.5
Cr12	0.621	5	0.675	4	0.729	2	0.782	2	0.836	2	7.67	2
$\frac{N(N+1)}{2}$ =		78		78		78		78		78		78

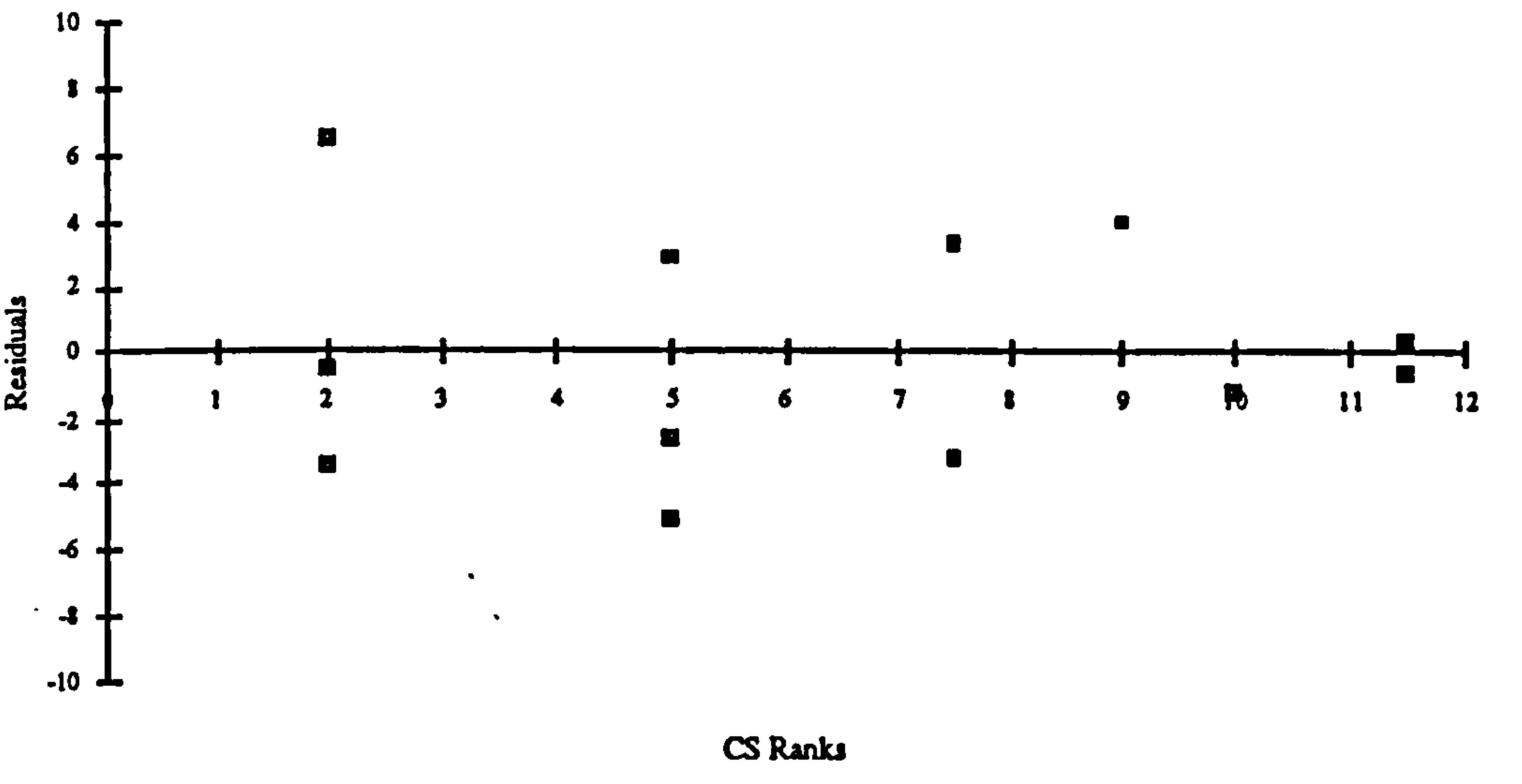
Resulting correlation coefficients (r_s) and respective levels of significance between each scenario, are given in columns 3 and 4 of Table 8.17.

Table 8.17.
Correlation coefficients between P3 scenarios and C_s: tenderers

Scenarios		All data		Outlier removed	
BSW_i	$P2W_i$	r_s	*signif*	r_s	*signif*
30%	70%	0.26	0.41	0.50	0.14
40%	60%	0.29	0.35	**0.54**	**0.05**
50%	50%	0.22	0.48	0.52	0.10
60%	40%	0.23	0.46	0.53	0.09
70%	30%	0.14	0.65	0.41	0.20

No statistically significant associations were discovered albeit the highest r_S is given to be with a ratio of $BSW_i = 0.4$ $P2W_i = 0.6$. This was first indication that greater weight should be attributed to P2 score than tender sum, reversing the ratio applied within the model thus far. By applying a linear regression to the median P3 scenario (ie., $BSW_i = 0.5$) upon C_S, it is shown from the plot of residuals in Figure 8.11. that value 6.51 (top left) is an outlier (cf. Kinnear & Gray, 1992).

Figure 8.11.
Plot of residuals for regression of P3 ranks for $BSW_i = 0.5$, upon C_S



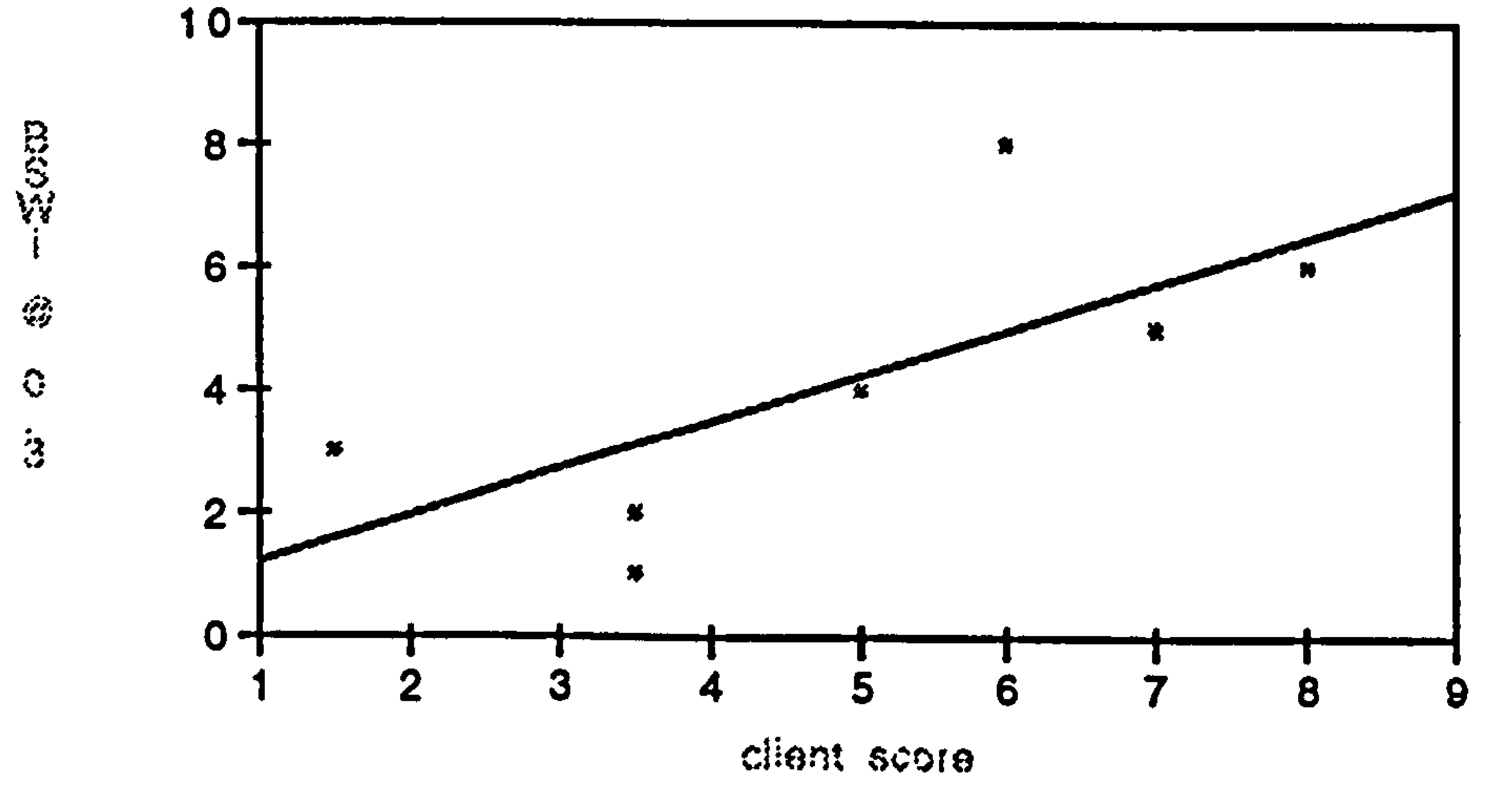
Outliers are readily identified on such plots due to their large negative (or positive in this case) value (Norusis, 1993). The removal of this discrepant value is recognised as a means of producing a more reliable analysis (Kinnear & Gray, 1992). Results on the correlation coefficients of such removal are exhibited in columns 3 & 4 of Table 8.17. We now see much stronger association, indeed, r_S becomes significant at the 95% level for $BSW_i = 0.4$. This reinforces the observation above regarding the lending of greater weight to $P2W_i$. If we concentrate upon the case study containing this discrepant value (this also containing the greater number of tenderers), then resulting coefficients (r_s) with and without the outlier, are as shown in Table 8.18.

Table 8.18.
Correlation coefficients: P3 and C_s for case study B

Scenarios		All data		Outlier removed	
BSW_i / $P2W_i$		r_s	signif	r_s	signif
30%	70%	0.35	0.39	**0.77**	**0.04**
40%	60%	0.30	0.46	0.70	0.07
50%	50%	0.12	0.77	0.59	0.15
60%	40%	-0.05	0.91	0.34	0.45
70%	30%	-0.05	0.91	0.34	0.45

It now becomes apparent that for $BSw_i = 0.3$ ($P2W_i = 0.7$) strong correlation with C_s exists ie., $r_s = 0.77$ significance: 96%. The linear regression of this BSW_i coefficient value upon C_s is shown in Figure 8.12.

Figure 8.12.
Linear regression of $BSW_i = 0.3$ upon Cs



Therefore, we can conclude at this stage that significant correlation exists between P3 score and C_s for BSW_i 0.3 to 0.4. This revision of the P3 coefficients is utilised in case study D below.

8.3. CASE STUDY D

Data for this case study were provided by STWA. In view that the client favoured a standing list and wished to continue with such at this time, P1 evaluation could not be performed because of data shortages (refer Case study A). However, the client issued P2 questionnaires with tender documentation thereby facilitating P2 and P3 computation for the six firms invited to tender.

Each contractor's bid rank, P2 and P3 scores / ranks are shown in Table 8.19. Tender sums are also detailed. Note that P3 is shown for both the original 40% P2 coefficient and the revised 60% coefficient.

Table 8.19.
Bids, P2 and P3 scores for case study D

Rank	Bids	P2 scores	P3 (40% P2)	P3 (60% P2)
1.	Cr1D (£375K)	Cr2D (0.46)	Cr1D (0.73)	Cr2D (0.63)
2.	Cr2D (£421K)	Cr5D (0.37)	Cr2D (0.71)	Cr1D (0.60)
3.	Cr3D (£498K)	Cr1D (0.33)	Cr3D (0.58)	Cr5D (0.50)
4.	Cr4D (£515K)	Cr3D (0.32)	Cr5D (0.57)	Cr3D (0.49)
5.	Cr5D (£527K)	Cr6D (0.25)	Cr4D (0.53)	Cr4D (0.43)
6.	Cr6D (£573K)	Cr4D (0.23)	Cr6D (0.49)	Cr6D (0.41)

Tender figures: mean value = £484K, standard deviation = £73K, range = £198K.

Using the ratio: 60% bid score, 40% P2 score, Cr1D achieved highest rank. However, as shown in section 8.2., a more significant correlation between P3 score and contractor performance is achieved using a ratio of 40% bid score, 60% P2 score. Based on the latter, Cr2D achieve top rank with a P3 score of 0.63 (Table 8.20).

Table 8.20.
Rank analysis: Case study D

	Bid	P2 score	P3 (60% bid)	P3 (40% bid)	Mean rank
Cr1D	1	3	1	2	1.75
Cr2D	2	1	2	1	**1.50**
Cr3D	3	4	3	4	3.50
Cr4D	4	6	5	5	5.00
Cr5D	5	2	4	3	3.50
Cr6D	6	5	6	6	5.75

In short, the model identifies Cr2D as best contractor for the project as confirmed by the highest mean rank for all measures discussed above. However, this subsequently begs the question -does the difference of £46K of Cr2D's tender above lowest tender submitted, represent value added?

Obviously this can only, ultimately, be decided by the client but, the dispersion of tender values, particularly the lowest figure submitted by Cr1D further raises the questions;

i) does the lowest tender figure indicate cash flow problems? (ie., achieve award at any price). Closer analysis of financial accounts may be required (eg., in this instance the current ratio based on 1993 accounts is well below the desired level of 1.5 to 1, at 0.87);
ii) is the tender misconceived?;
iii) is the tender value *suicidally* low? (cf. Merna & Smith, 1990).

Indeed, the £46K represents almost one quarter of the entire range of all bids submitted. The relationship between P scores achieved and C_S is investigated in section 8.5.

8.4. SUMMARY ANALYSIS OF P SCORES, CASE STUDIES A TO D

We may summarise P scores achieved amongst *all* contractors evaluated, as shown in Table 8.21. The median is observed to offset influence of extreme values amongst the data as identified earlier (8.1.6.2).

Table 8.21.
Summary analysis of P scores achieved where C_S for NSG contractors ≤ 5.0

Model component	All sample	Good contractors	NSG contractors
C_S	6.68	6.88	5.00
P1	0.51	0.61	0.44
P2	0.45	0.44	0.50
P3[a]	0.74	0.73	0.77
P3[b]	0.63	0.63	0.65

[a] Using 40% P2 input
[b] Using revised 60% P2 input

As previously elucidated, P1 is most able to discriminate between 'good and not so good' whilst P2 is less so -P1 analysis having reduced disparity between the sets. This is also the case for P3, albeit the revised BSW_i offsets this. However, it is noted that in terms of classification thus far, Good = $C_S > 5.0$. Hence, a firm achieving an average of *only* 51% for client time, cost and quality past performance ratings is classified 'good'. Rationale behind using this demarcation point has been explained.

Nonetheless, to introduce a more stringent pass mark for 'good' contractors (i.e., Good = Cs > 0.7) produces a matrix of values as shown in Table 8.22.

Table 8.22.
Summary analysis of P scores
achieved where C_S for NSG contractors ≤ 7.0

Model component	All sample	Good contractors	NSG contractors
Cs	6.68	7.31	6.04
P1	0.51	0.62	0.47
P2	0.45	0.45	0.43
P3[a]	0.74	0.75	0.71
P3[b]	0.63	0.67	0.63

[a] Using 40% P2 input
[b] Using revised 60% P2 input

Here is conclusive evidence that the better P scores, are achieved by those contractors who are indeed 'best' in terms of time, cost and quality potential.

8.5. POOLED MULTIVARIATE CONTRACTOR DATA -INVESTIGATION OF TAXONOMIES

So far, this chapter has investigated the model outputs in a fractional manner. This approach has facilitated *inter-alia* the identification of trends, significant relationships and levels of association / correlation, between: attribute scores, factor scores, P scores and C_S.

As a conclusion, indeed, acid test as to whether the model can truly discriminate between, and therefore classify, those contractors evaluated, the pooled model output (multivariate) data (that is, aggregated P1 data and, aggregated P2 data) were subjected to analysis. The fundamental object of this exercise was to (via statistical processing) develop or organise the data into meaningful structures and, interpret those structures. That is, to develop taxonomies. If we consider the C_S method of contractor classification applied thus far, then the optimal situation arising from such analysis would be two taxons, as distinct from each other as possible, *viz*; 'good' and 'not-so-good' contractors.

If the members of these resulting taxons perfectly mirrored the membership of the same named groups whose *original* membership had been established via the C_S scores, then, we may assume that the model certainly does have the ability to correctly classify contractors evaluated. Such clear distinction between groups would be an optimum result. Obviously to what extent the taxons emulate the former groups, will identify how effective the model actually is.

To establish taxons from pooled model data, the statistical technique of cluster analysis was used. A complete introduction to this technique may be observed in Everitt, (1980). For the purposes of this thesis, an overview is given.

8.5.1. An overview of the cluster analysis technique

Cluster analysis takes a given number of objects (contractors), each of which is described by a given set of numerical measures (attribute scores) and, uses a classification scheme (algorithm) to group the objects into a number of classes (clusters), such, that objects within classes are similar in some respects and unlike those from other classes (ibid).

There is similarity in the mathematical approach of cluster analysis algorithms, to those of MAA explained in Chapter 5, in so far as raw data subjected to analysis consist of an (n x m) matrix of measurements;

$$
\begin{array}{ccccc}
x_{11} & x_{12} & \cdot & \cdot & x_{1m} \\
x_{21} & x_{22} & \cdot & \cdot & x_{2m} \\
\vdots & \cdot & \cdot & \cdot & \cdot \\
\vdots & \cdot & \cdot & \cdot & \cdot \\
x_{n1} & \cdot & \cdot & \cdot & x_{nm}
\end{array}
$$

where: n is the nth object being measured in respect of m measures (cf. Table 5.1).

In this instance the objective functions x_{nm} are the attribute scores, that were utilised within the model in respect of n contractors. The result of cluster analysis upon this matrix will be a number of groups 1, 2, . . . , j where: $\sum$ 1, 2, . . . j's membership is equal to the original sample value: n. Two different types of cluster analysis are used in the following examination, both having their own particular features and hence, specific uses. The two methods are: jointing tree clustering and k-means clustering.

8.5.1.1. Jointing tree clustering

This method is firstly applied to the data in order to establish the most significant number of clusters *inherent within it.* That is, amongst the pooled contractor data we have (assume) no priori hypothesis with regard to such (albeit as stated, that in this instance the optimum situation would be two clusters).

Analysis output is a tree diagram known as a dendrogram. The lowermost part of the dendrogram (ie., the x axis) exhibits each contractor in a class by itself. As we progress upwards, the criteria as to what is, and is not, unique are relaxed, ie, the threshold regarding the decision when to declare two or more objects as being similar are relaxed. As a result, more and more contractors are linked (amalgamated) to form larger clusters, until finally in the last step (ie., the uppermost part of the dendrogram), all contractors are linked together.

Thus, for each node in the graph where a new cluster is formed, we can read off the criterion distance (ie., the y axis) at which the respective elements are linked together into a new single cluster. When the data contain a clear 'structure' in terms of clusters of objects that are similar to each other, then this structure will be reflected in the hierarchical tree as distinct branches. Distance between nodes (branches) of the tree is proportional to the difference (dissimilarity) between objects. Hence, as the result of a successful analysis with the joining tree method, one is able to detect the distinct clusters (branches) being sought and, interpret those branches.

There are many algorithms that may be applied to establish clusters. However, the most straightforward way of establishing distance (degree of difference) between objects (contractors) in a multi-dimensional space is to compute *Euclidian* distances. Whether we have a two, or three dimensional space, this measure is the actual geometric distance between objects in that space. Euclidian distance is also the most commonly used type of distance, being computed as;

$$d_{ij} = \sqrt{\left\{\Sigma\ (x_{ij} - x_{jk})^2\right\}}$$

where; d_{ij} is the distance between two points i and j and x_{ik} is the value of the kth variable for the ith entity.

In summary, joining tree clustering identifies and graphically shows via a dendrogram, the number of 'natural' clusters within the given set of data.

8.5.1.2. *k*-means clustering

k-means clustering is a method whereby *k* number of clusters are formed from the data but the value of k ie., required number of clusters, is at the researchers discretion. For example: if the joining tree method has identified three natural clusters ('good', bad, indifferent) then a k-means analysis (k = 2) would establish two clusters but, each of these two would contain a proportion of the third and hence, distinction between them be slightly reduced.

Strategically, the method may be thought of as analysis of variance (ANOVA) in reverse. That is, we start with *k* random clusters, moving objects between those clusters with the goal to; i) minimise variability within clusters and ii) maximise variability between clusters.

This is analogous to ANOVA in reverse in the sense that the significance test in ANOVA evaluates the between group variability against the within-group variability, when computing the significance test for the hypothesis that the means in the groups are different from each other. In k-means clustering, objects (e.g.,cases) are moved in and out of groups (clusters) to get the most significant ANOVA results (see analysis of variance Tables later).

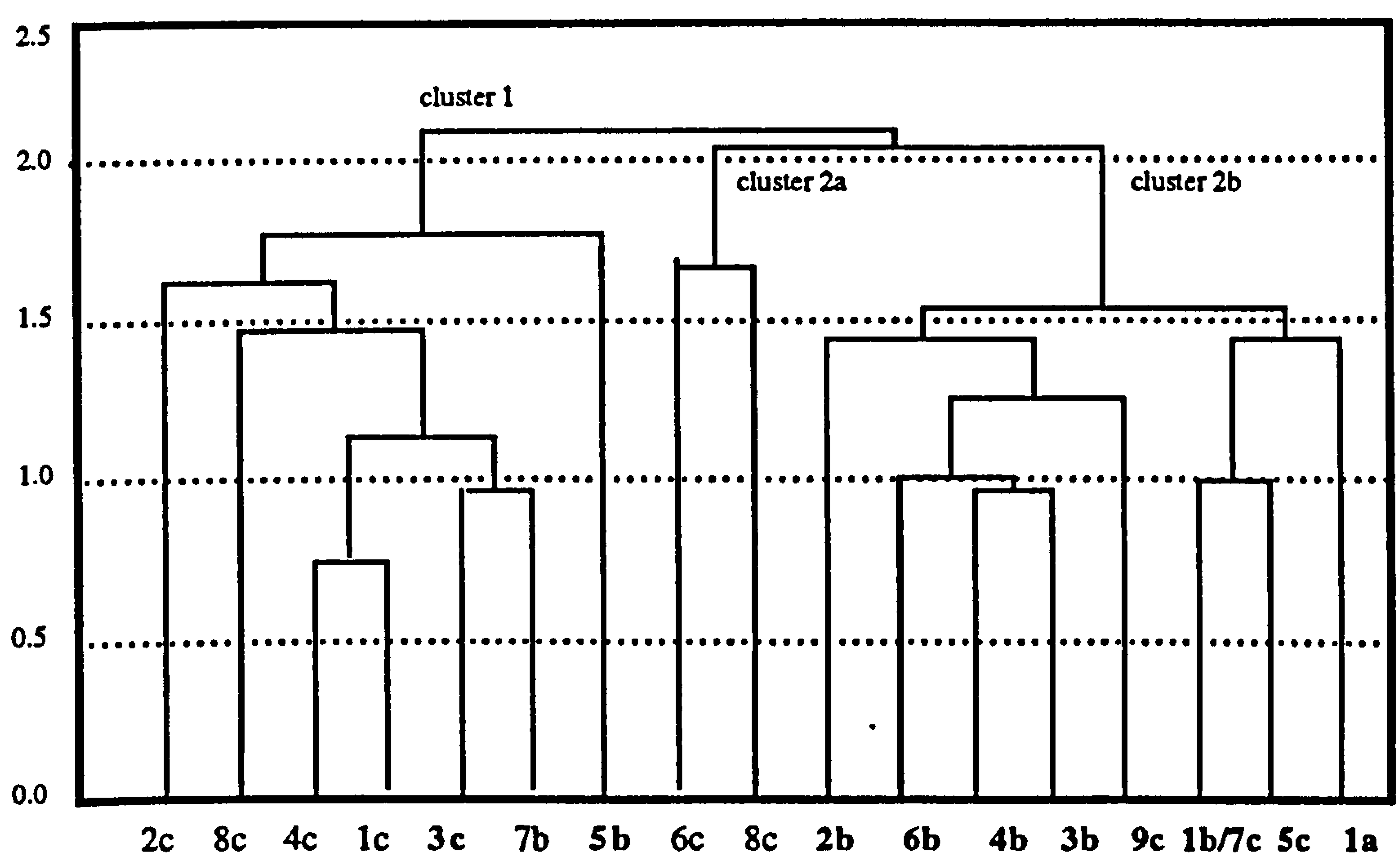
In summary, k-means clustering is best performed once an hypothesis regarding the number of clusters within the data is known. As a result of the analysis, the means for each dimension (attribute) within the cluster may be examined to establish how *distinct* the *k* clusters are. Further, *k*-means analysis will also confirm the most discriminating criteria (controlling variables) amongst the clusters.

In this instance, these controlling variables will be compared with the results of fractional analysis upon contractor data earlier in this chapter and the correlation between these two sets of variables observed. The results have ramifications with regard to rationalising the contractor evaluation process further (ie., utilise fewer but the most discriminating variables) and a possible future, multiple regression model. These points are discussed at the end of the Chapter.

8.5.2. Cluster analysis using V_i score measures -P1 data

Firstly, a jointing tree analysis was performed on the eighteen P1 cases from project case studies A to C, utilising the attribute scores achieved (V_i) as measures. As can be seen from Figure 8.13. two principal clusters were identified, the second of which subsequently branched into two. These three clusters have been classified as cluster 1, cluster 2a, and cluster 2b. The horizontal axis in Figure 8.13. identifies the eighteen contractors -with those in bold face indicating 'good' firms (ie., $C_S > 5$).

Figure 8.13.
Dendrogram: P1 data -unweighted pair-group average Euclidian distances (Vi score measures)



Vertical axis = linkage distances
Horizontal axis: contractors identified in bold = good firms as defined via C_S

The cluster members are listed in Table 8.23. along with their respective distances from each (respective) cluster centre. These distances are a measure of how well the cases fit within each cluster with the smaller distance representing the best fit.

Table 8.23.
P1 data cluster member details (V_i score measures)

	Contractor	Distance†	Classification
Cluster 1 -7 cases	2c	0.279	NSG
	8c	0.261	NSG
	4c	0.180	NSG
	1c	0.156	NSG
	3c	0.130	GOOD
	7b	0.154	NSG
	5b	0.293	GOOD
Cluster 2a -2 cases	6c	0.177	NSG
	8b	0.177	NSG
Cluster 2b -9 cases	2b	0.255	GOOD
	6b	0.170	GOOD
	4b	0.157	GOOD
	3b	0.171	GOOD
	9c	0.193	GOOD
	1b	0.193	GOOD
	7c	0.214	GOOD
	5c	0.232	GOOD
	1a	0.231	GOOD

†Distance from respective cluster centre

It is clearly shown that all but two of the 'good' contractors have been correctly assigned to cluster 2b or, to put it another way, the model outputs were consistent for all but Cr3C and Cr5B. Regarding the latter it can be seen from the Table that albeit the firm is classified as 'good' it is furthest away from cluster centre, ie., exhibits the worst fit. The NSG contractors are predominantly clusters 1 and 2a, cluster 2b is 100 percent 'good' contractors. This is an excellent result showing strong correlation between model output (in terms of P1 attribute scores) and client perception of contractor ability.

Table 8.24. compares the mean value, standard deviation and variance for all P1 measures (ie., V1, V2,...,V21) amongst each of these three clusters.

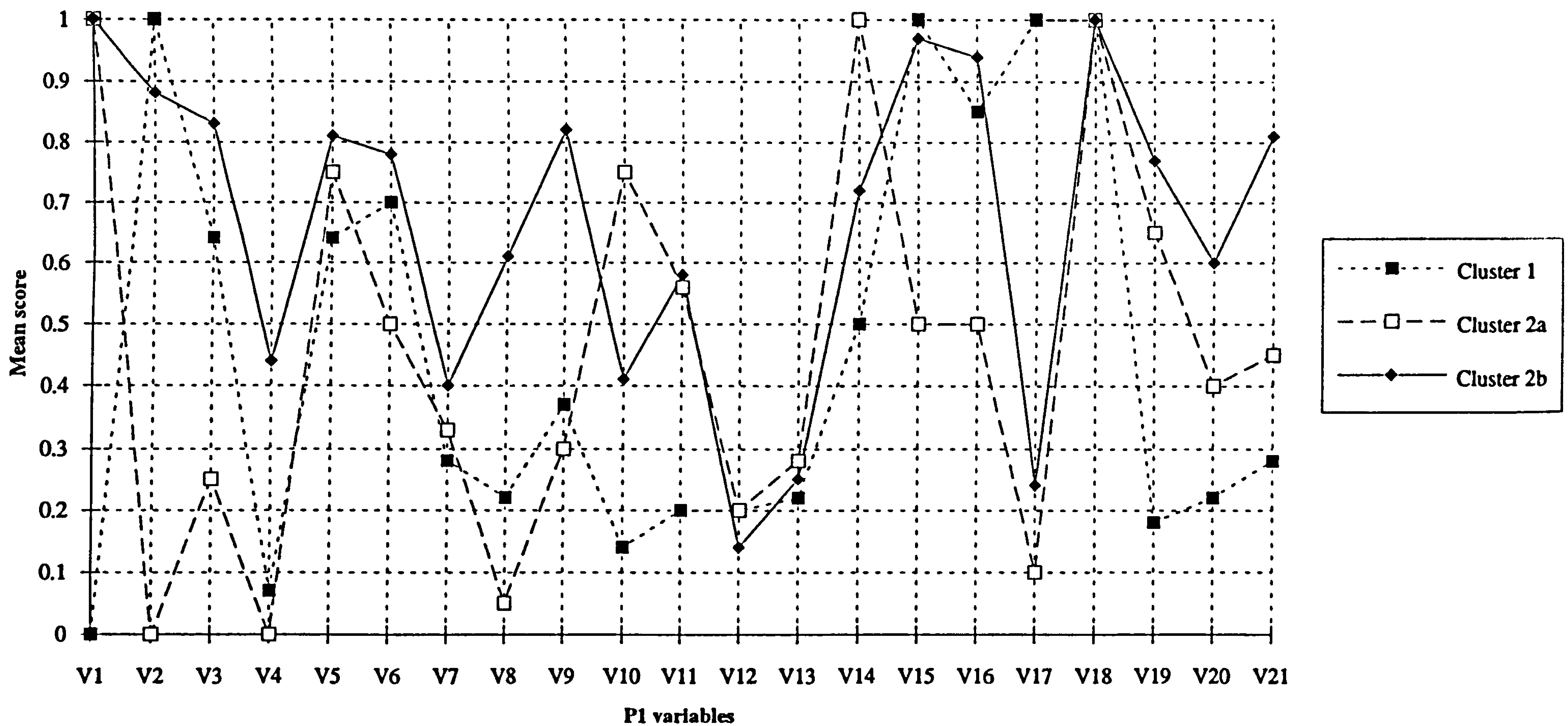
Table 8.24.
P1 data: means, standard deviation and variance of cluster members (Vi score measures)

	Cluster 1			Cluster 2a			Cluster 2b		
	m†	*sd*††	*v*†††	*m*	*sd*	*v*	*m*	*sd*	*v*
V_1	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
V_2	1.00	0.00	0.00	0.00	0.00	0.00	0.88	0.33	0.11
V_3	0.64	0.37	0.14	0.25	0.35	0.12	0.83	0.25	0.06
V_4	0.07	0.18	0.03	0.00	0.00	0.00	0.44	0.39	0.15
V_5	0.64	0.07	0.00	0.75	0.07	0.00	0.81	0.11	0.01
V_6	0.70	0.07	0.00	0.50	0.00	0.00	0.78	0.16	0.02
V_7	0.28	0.24	0.06	0.33	0.00	0.00	0.40	0.18	0.03
V_8	0.22	0.28	0.07	0.05	0.07	0.00	0.61	0.30	0.09
V_9	0.37	0.33	0.11	0.30	0.42	0.18	0.82	0.14	0.02
V_{10}	0.14	0.28	0.08	0.75	0.00	0.00	0.41	0.12	0.01
V_{11}	0.20	0.17	0.03	0.56	0.21	0.04	0.58	0.22	0.05
V_{12}	0.20	0.15	0.02	0.20	0.00	0.00	0.14	0.16	0.02
V_{13}	0.22	0.25	0.06	0.28	0.39	0.15	0.25	0.24	0.06
V_{14}	0.50	0.40	0.16	1.00	0.00	0.00	0.72	0.26	0.06
V_{15}	1.00	0.00	0.00	0.50	0.70	0.50	0.97	0.08	0.00
V_{16}	0.85	0.37	0.14	0.50	0.00	0.00	0.94	0.16	0.02
V_{17}	1.00	0.00	0.00	0.10	0.00	0.00	0.24	0.19	0.03
V_{18}	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00
V_{19}	0.18	0.15	0.02	0.65	0.49	0.24	0.77	0.19	0.03
V_{20}	0.22	0.26	0.06	0.40	0.14	0.02	0.60	0.34	0.12
V_{21}	0.28	0.32	0.10	0.45	0.21	0.04	0.81	0.12	0.01

† *Mean variable score amongst cluster*
†† *Standard deviation for variable score amongst cluster*
††† *Variance for variable score amongst cluster*

Cursory perusal of the figures indicates the differences between clusters. For example, cluster 2b (the 'good' set) generally has higher V scores than the other two clusters. However, there is less obvious disparity between 2a and 2b. Therefore, we may graphically observe the differences between mean values of the attribute scores for each cluster in Figure 8.14.

Figure 8.14. Plot of mean v scores for P1 (attribute scores) data, clusters 1, 2a and 2b



Such graphical comparison of scores shows more clearly the differences between clusters. Hence, from Figure 8.14. the most discriminating variables (ie., those with greatest disparity between the clusters) can be seen. Qualitatively, these appear to include V1, V2, V3, V4, V8, V9, V10, V15, V16, V17 and V19 to V21 inclusive.

Observation of these differences in mean v scores is investigated quantitatively in Table 8.25., this giving analysis of variance between, and within, clusters. Probability values are shown in the right hand column.

Table 8.25.
P1 data: analysis of variance (V_i score measures)

	Between clusters		Within clusters		Significance
	df.	*SS*	*df.*	*SS*	*p.*
V1	2	4.27	15	0.00	**0.000**
V2	2	1.61	15	0.88	**0.000**
V3	2	0.58	15	1.48	0.081
V4	2	0.68	15	1.43	**0.053**
V5	2	0.11	15	0.15	**0.015**
V6	2	0.14	15	0.24	0.320
V7	2	0.05	15	0.65	0.521
V8	2	0.85	15	1.22	**0.003**
V9	2	0.96	15	1.04	**0.007**
V10	2	0.66	15	0.60	**0.004**
V11	2	0.59	15	0.64	**0.007**
V12	2	0.01	15	0.35	0.713
V13	2	0.00	15	1.04	0.965
V14	2	0.44	15	1.55	0.151
V15	2	0.42	15	0.55	**0.014**
V16	2	0.32	15	1.07	0.140
V17	2	0.09	15	0.30	0.131
V18	2	zero	15	zero	zero
V19	2	1.41	15	0.68	**0.000**
V20	2	0.54	15	1.39	0.083
V21	2	1.11	15	0.82	**0.001**

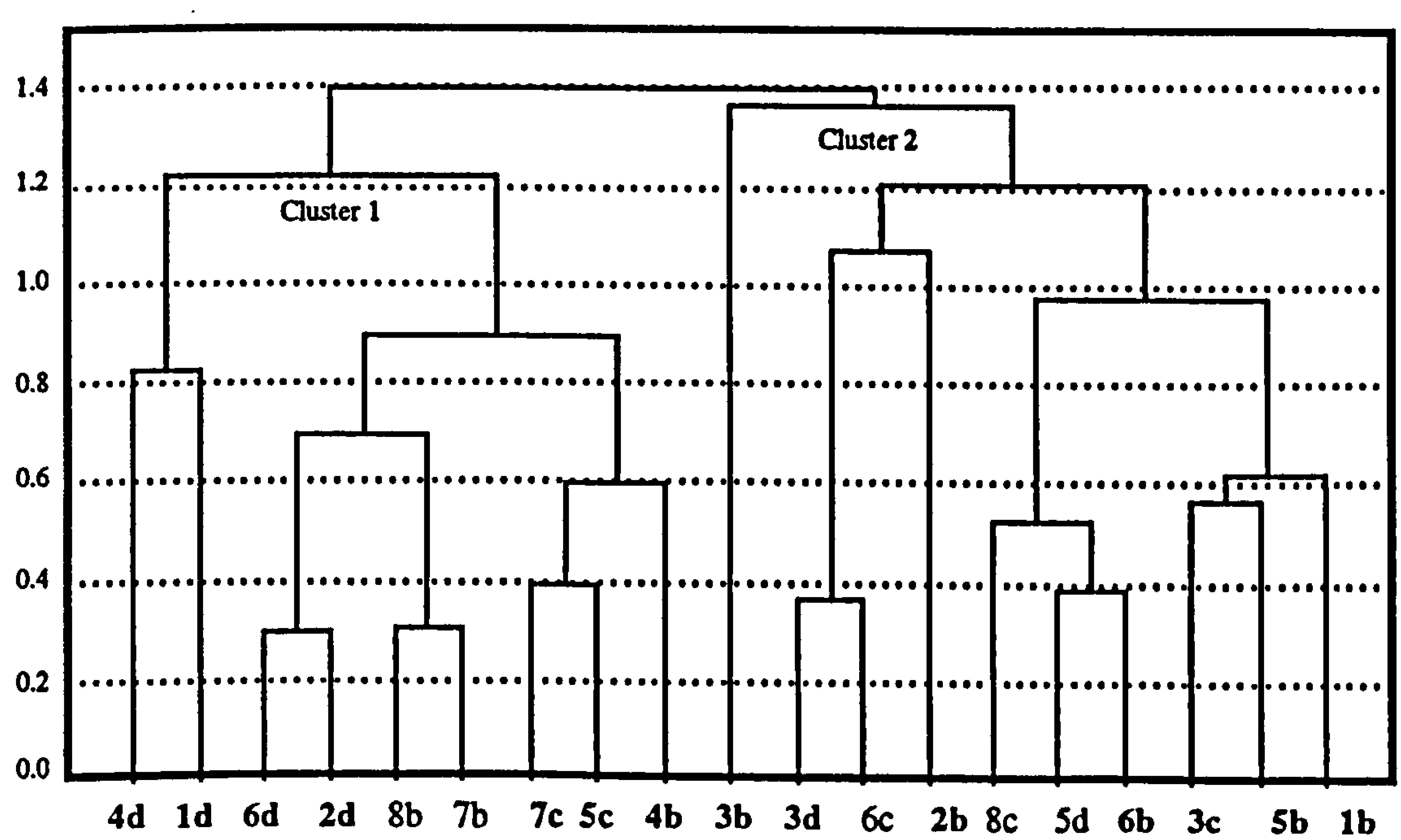
From the Table, it can be seen that the eleven controlling variables are;

	Level of significance
V1: size of contractor (resources)	99%
V2: age of the company	99%
V4: quality control policy	95%
V5: health & safety policy	99%
V8: bank reference	99%
V9: credit references	99%
V10: turnover history	99%
V11: qualification of company owners	99%
V15: experience -type of projects	99%
V19: past performance -time overruns	99%
V21: past performance -quality achieved	99%.

8.5.3. Cluster analysis using V_k measures -P2 data

A jointing tree analysis was applied to the tenderers from all four case studies, utilising V_k attribute scores as measures. Figure 8.15. shows the resulting two clusters.

Figure 8.15.
Dendrogram: P2 data -unweighted pair-group average Euclidian distances (Vk score measures)



Vertical axis = linkage distances
Horizontal axis: contractors identified in bold = good firms as defined via C_s

Mirroring earlier analyses in this Chapter, there was less distinction between the 'good' and NSG contractors. This is a result of the measures bearing more resemblance between them. That is, some of the most extreme values having been removed during P1 analysis. Table 8.26. confirms this: cluster one contains 77% good contractors and cluster two 70% good contractors.

Table 8.26.
P2 data cluster member details (V_k score measures)

	Contractor	Distance†	Classification
Cluster 1 -9 cases	Cr4b	0.278	GOOD
	Cr7b	0.122	NSG
	Cr8b	0.170	NSG
	Cr5c	0.239	GOOD
	Cr7c	0.235	GOOD
	Cr4d	0.328	GOOD
	Cr2d	0.178	GOOD
	Cr1d	0.310	GOOD
	Cr6d	0.167	GOOD
Cluster 2 -10 cases	Cr1b	0.151	GOOD
	Cr2b	0.332	GOOD
	Cr3b	0.403	GOOD
	Cr5b	0.253	GOOD
	Cr6b	0.157	GOOD
	Cr3c	0.280	GOOD
	Cr6c	0.345	NSG
	Cr8c	0.190	NSG
	Cr3d	0.305	GOOD
	Cr5d	0.219	Unclassified*

†Distance from respective cluster centre * Client has no previous experience with this firm

This lower contrast between clusters is confirmed by the mean attribute scores between them shown graphically in Figure 8.16 and detailed in Table 8.27. The controlling variables are;

V27: current workload capacity	99%
V28: previous client relationship	95%
V29: home office location to proposed project	99%

-as confirmed by the analysis of variance in Table 8.28.

Figure 8.16. Plot of mean v scores for P2 (attribute scores) data, clusters 1 and 2

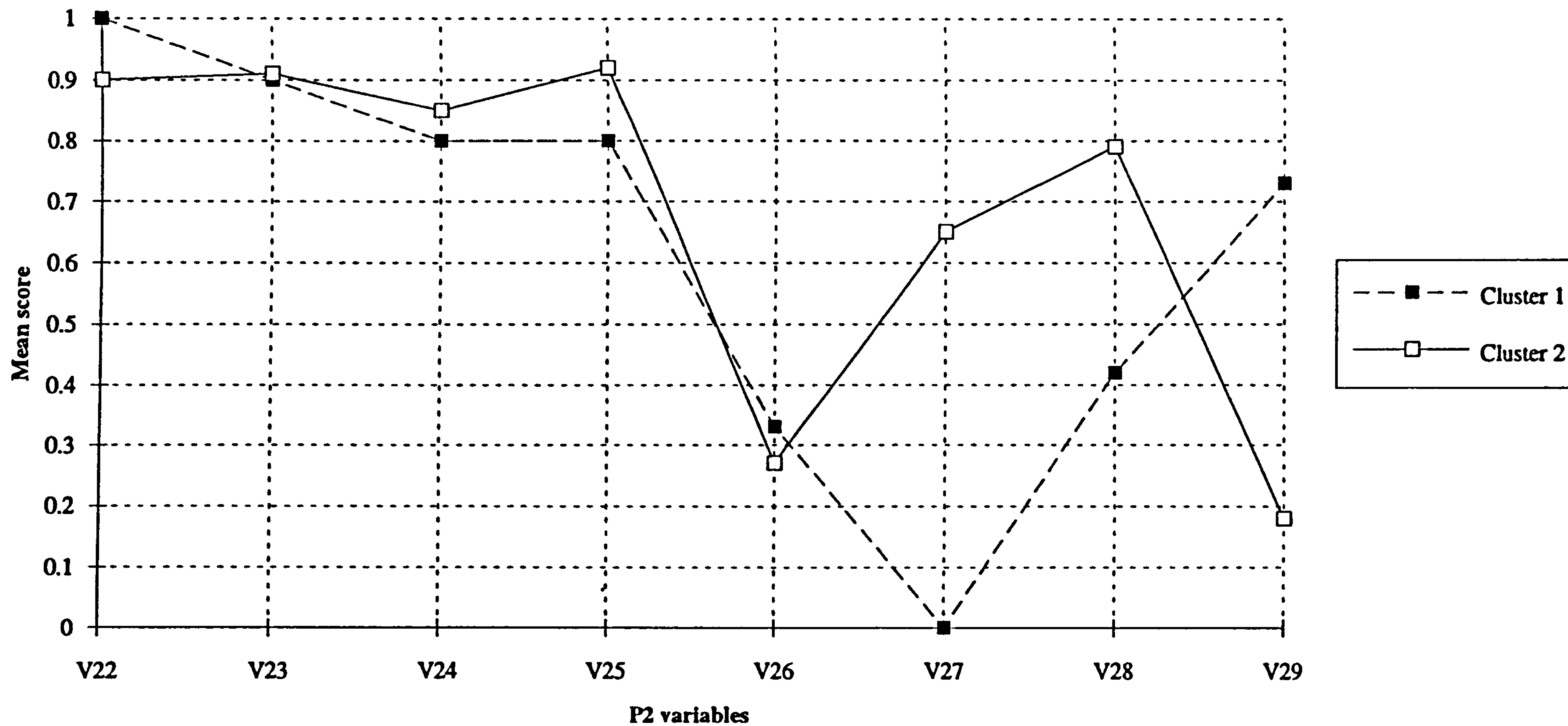


Table 8.27.
P2 data: means, standard deviation and variance of cluster members (V_k score measures)

	Cluster 1			Cluster 2		
	m†	*sd*††	*v**	*m*	*sd*	*v*
V22	1.00	0.00	0.00	0.90	0.31	0.10
V23	0.90	0.10	0.01	0.91	0.13	0.01
V24	0.80	0.20	0.04	0.85	0.21	0.04
V25	0.80	0.17	0.02	0.92	0.12	0.01
V26	0.33	0.17	0.03	0.27	0.16	0.02
V27	0.00	0.00	0.00	0.65	0.47	0.22
V28	0.42	0.44	0.20	0.79	0.31	0.09
V29	0.73	0.42	0.18	0.18	0.38	0.14

†Mean variable score amongst cluster. ††Standard deviation for variable score amongst cluster. *Variance for variable score amongst cluster.

Table 8.28.
P2 data: analysis of variance (V_k score measures)

	Between clusters		Within clusters		Significance
	df.	*SS*	*df.*	*SS*	*p.*
V22	1	0.04	17	0.90	0.357
V23	1	0.00	17	0.25	0.911
V24	1	0.00	17	0.74	0.650
V25	1	0.06	17	0.38	0.102
V26	1	0.01	17	0.49	0.440
V27	1	2.00	17	2.02	**0.000**
V28	1	0.64	17	2.50	**0.052**
V29	1	1.45	17	2.76	**0.008**

8.5.4. Summary of cluster analysis using variable score measures

The results of this analysis were encouraging. Beyond doubt the model distinguishes between 'good' and not-so-good during P1 analysis as confirmed by the dendrogram ie., all but two of the cases were correctly classified. Eleven significant attribute measures were identified.

P2 analysis is less distinct for the reasons previously discussed concerning the disparity between contractors once P1 analysis has taken place. Two P2 clusters were formed and three controlling attribute measures identified.

Having investigated the classification of firms based on V_i scores the next step was to observe the results of similar analysis using *rationalised v scores* as measures. The following investigation concentrates upon raw V scores multiplied by their relevant weighting indices. As a reminder, rationalised scores are a function of;

rationalised P1 score = $V_i \times W_i$ and;
rationalised P2 score = $V_k \times W_k \times U_k$.

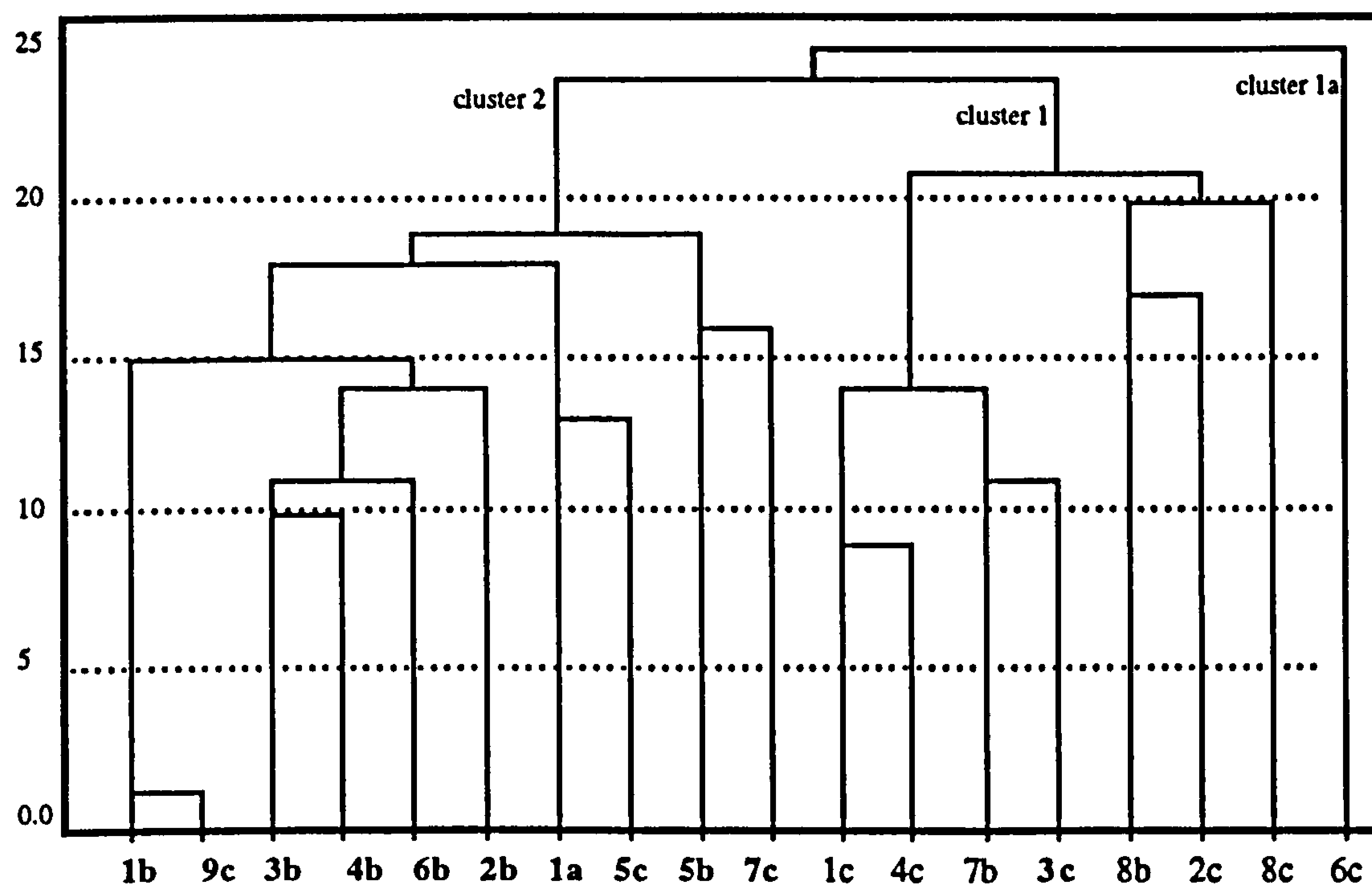
8.5.5. Cluster analysis using rationalised v scores - P1 data

A jointing tree analysis was performed on the eighteen P1 cases using rationalised V_i scores. The dendrogram in Figure 8.17 shows that three clusters (1, 1a and 2) were inherent.

However, it can be seen that Cr6c is identified as a 'rogue' ie., forms a cluster by itself. A k-means cluster analysis was performed ($k = 2$) with Cr6c resulting a member of cluster 1. A subsequent k-means ($k = 3$) formed three clusters with Cr6c being a single member (as per dendrogram). We may therefore discuss the results of $k = 3$ because with Cr6c being isolated, we may identify *why* it was singled out.

Cluster members are shown in Table 8.29. along with distances from relevant cluster centres and classification of contractors ('good' / NSG). Previous cluster membership (based on V_i scores alone refer section 8.5.2.) is also shown in italics for comparison purposes.

Figure 8.17
Dendrogram: P1 data -unweighted pair-group average Euclidian distances (rationalised V score measures)



Vertical axis = linkage distances
Horizontal axis: contractors identified in bold = good firms as defined via C_s

The overall result is better than that previously achieved by using V_i measures. This is because all but one of the 'good' contractors has been correctly grouped into one cluster. The outcome is particularly inspiring because it proves that by multiplying V_i scores by their relevant weighting indices W_i (derived from the survey in Chapter 4) a more reliable output is ascertained.

The mean rationalised scores for each cluster are shown graphically in Figure 8.18. This not only highlights the differences between the two principal clusters but also, the reason that Cr6c is a 'rogue'.

Figure 8.18. Plot of mean rationalised v scores for P1 data clusters 1, 1a and 2

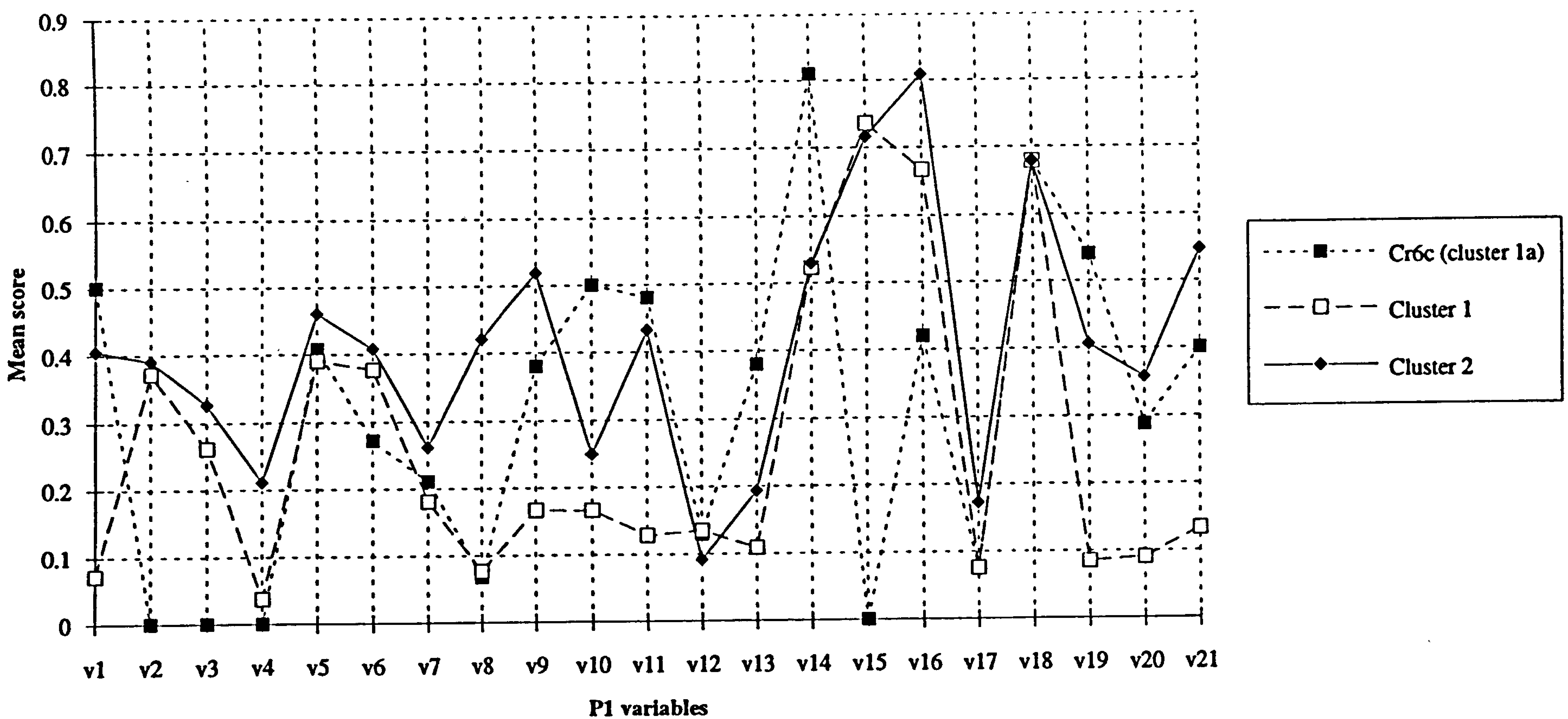


Table 8.29.
P1 data cluster member details (rationalised V score measures)

	Contractor	Distance†	Classification	Previous††
Cluster 1 -7 cases	1c	0.485	NSG	*1*
	4c	0.694	NSG	*1*
	7b	0.539	NSG	*1*
	3c	0.471	GOOD	*1*
	8b	0.828	NSG	*2a*
	2c	0.678	NSG	*1*
	8c	0.810	NSG	*1*
Cluster 1 a -1 case	6c	0.000	NSG	*2a*
Cluster 2 -10 cases	1b	0.582	GOOD	*2b*
	9c	0.582	GOOD	*2b*
	3b	0.482	GOOD	*2b*
	4b	0.406	GOOD	*2b*
	6b	0.461	GOOD	*2b*
	2b	0.635	GOOD	*2b*
	1a	0.660	GOOD	*2b*
	5c	0.688	GOOD	*2b*
	5b	0.822	GOOD	*1*
	7c	0.685	GOOD	*2b*

†Distance from respective cluster centre

†† Previous cluster membership based on non-rationalised v scores refer Table 8.23.

Clearly, the 'good' contractors achieve a higher mean rationalised score in the majority of variables whilst the converse is true for the NSG contractors. The fact that Cr6c is singled out appears a function of the firms mean scores being generally, somewhere between the former two.

In short, Cr6c is neither 'good' or 'not so good' in terms of both V scores and, rationalised V scores but has been classified as NSG by the client.

Analysis of variance in Table 8.30. identifies the controlling (rationalised) variables.

Table 8.30.
P1 data: analysis of variance (rationalised V_i score measures)

	Between		Within		Significance	
	df.	*SS*	*df.*	*SS*	*F*	*p.*
V1	2	0.255	15	0.038	6.633	**0.009**
V2	2	0.070	15	0.022	3.170	0.071
V3	2	0.051	15	0.016	3.151	0.072
V4	2	0.071	15	0.030	2.374	0.127
V5	2	0.010	15	0.004	2.198	0.145
V6	2	0.009	15	0.006	1.503	0.254
V7	2	0.014	15	0.017	0.791	0.471
V8	2	0.266	15	0.026	10.03	**0.002**
V9	2	0.255	15	0.019	12.90	**0.001**
V10	2	0.052	15	0.030	1.717	0.213
V11	2	0.204	15	0.005	36.68	**0.000**
V12	2	0.004	15	0.010	0.410	0.671
V13	2	0.039	15	0.028	1.378	0.282
V14	2	0.039	15	0.083	0.469	0.634
V15	2	0.248	15	0.002	122.2	**0.000**
V16	2	0.090	15	0.055	1.618	0.231
V17	2	0.021	15	0.012	1.750	0.207
V18	2	0.000	15	0.000	-	-
V19	2	0.246	15	0.008	29.98	**0.000**
V20	2	0.146	15	0.023	6.309	**0.010**
V21	2	0.352	15	0.010	33.44	**0.000**

From the Table, it can be seen that these are;

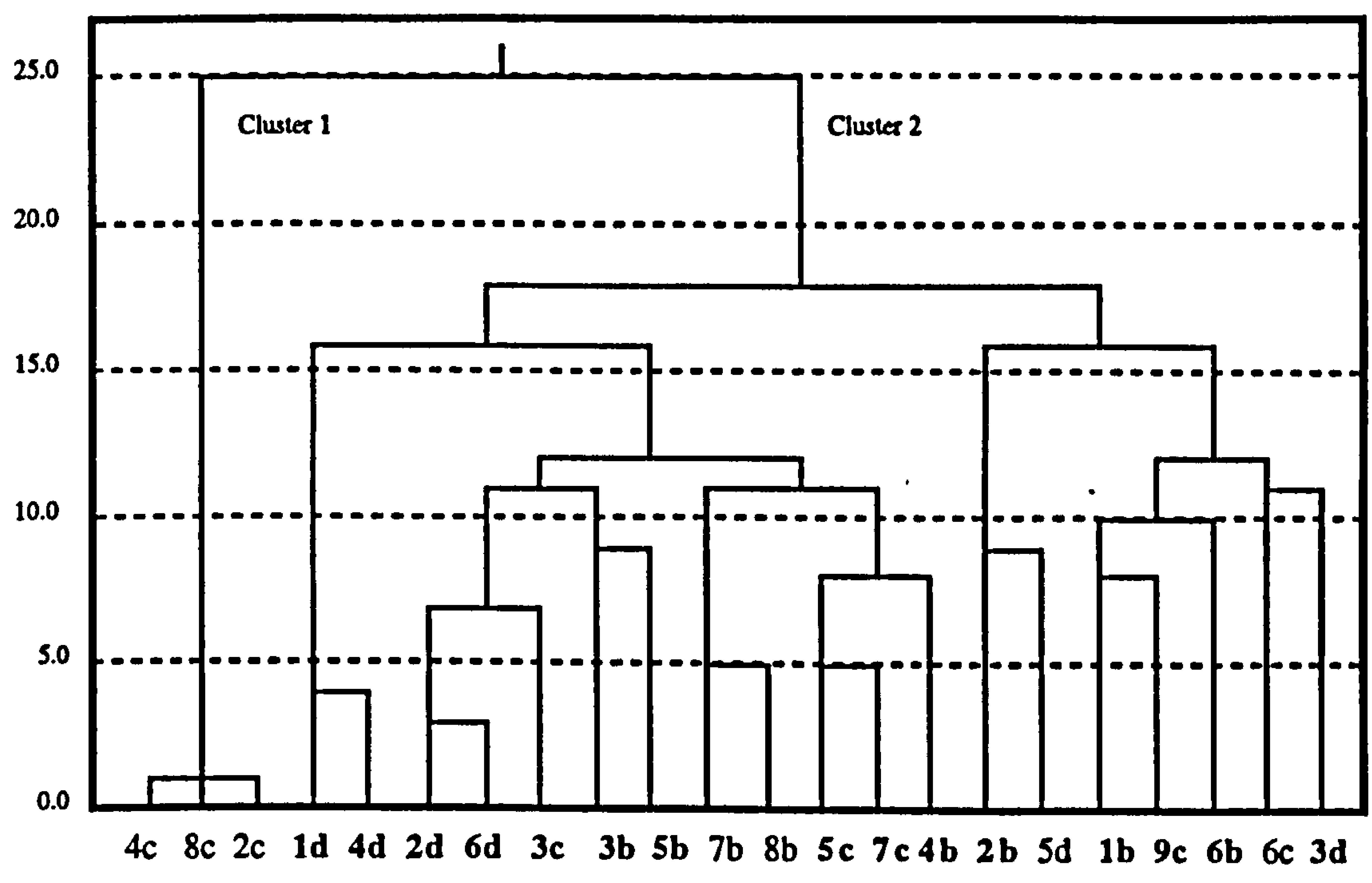
V1: size of contractor (resources);
V8: bank reference;
V9: credit references;
V11: qualification of company owners;
V15: experience -type of projects;
V19: past performance -time overruns;
V20: past performance -cost overruns;
V21: past performance -quality achieved;

-each being significant at the 99% level. All of the above eight were previously included in the (V_i measure) list of controlling variables.

8.5.6. Cluster analysis using rationalised v scores - P2 data

A jointing tree analysis on all P2 cases using rationalised V_k score measures, produced the dendrogram shown in Figure 8.19. Of the two clusters, cluster 1 consisted of three NSG contractors. Cluster 2 sub-divides further into two, amongst which *all* of the 'good' contractors are included.

Figure 8.19.
Dendrogram: P2 data unweighted pair-group average euclidean distances (rationalised V score measures)



Vertical axis = linkage distances
Horizontal axis: contractors identified in bold = good firms as defined via C_s

In view of this result, a k-means (k=2) analysis was performed. Table 8.31 details resulting cluster members.

Table 8.31.
P2 data: cluster member details (rationalised V_k score measures)

Contractor	Distance	Classification
Cluster 1 - 14 cases		
1b	0.395	GOOD
3b	0.311	GOOD
4b	0.379	GOOD
5b	0.337	GOOD
7b	0.307	NSG
8b	0.274	NSG
3c	0.240	GOOD
5c	0.258	GOOD
7c	0.276	GOOD
9c	0.430	GOOD
1d	0.486	GOOD
2d	0.168	GOOD
4d	0.468	GOOD
6d	0.186	GOOD
Cluster 2 - 8 cases		
2b	0.432	GOOD
6b	0.388	GOOD
2c	0.409	NSG
4c	0.409	NSG
6c	0.359	NSG
8c	0.409	NSG
3d	0.362	GOOD
5d	0.418	Unclassified

Figure 8.20. charts mean criteria values amongst the clusters. Three controlling variables are visible;

V25: key persons available for the project;

V26: qualification of key personnel available for the project;

V27: current workload capacity;

- each significant at the 95% level, as confirmed by Table 8.32.

Figure 8.20. Plot of mean rationalised v scores for P2 data, clusters 1 and 2

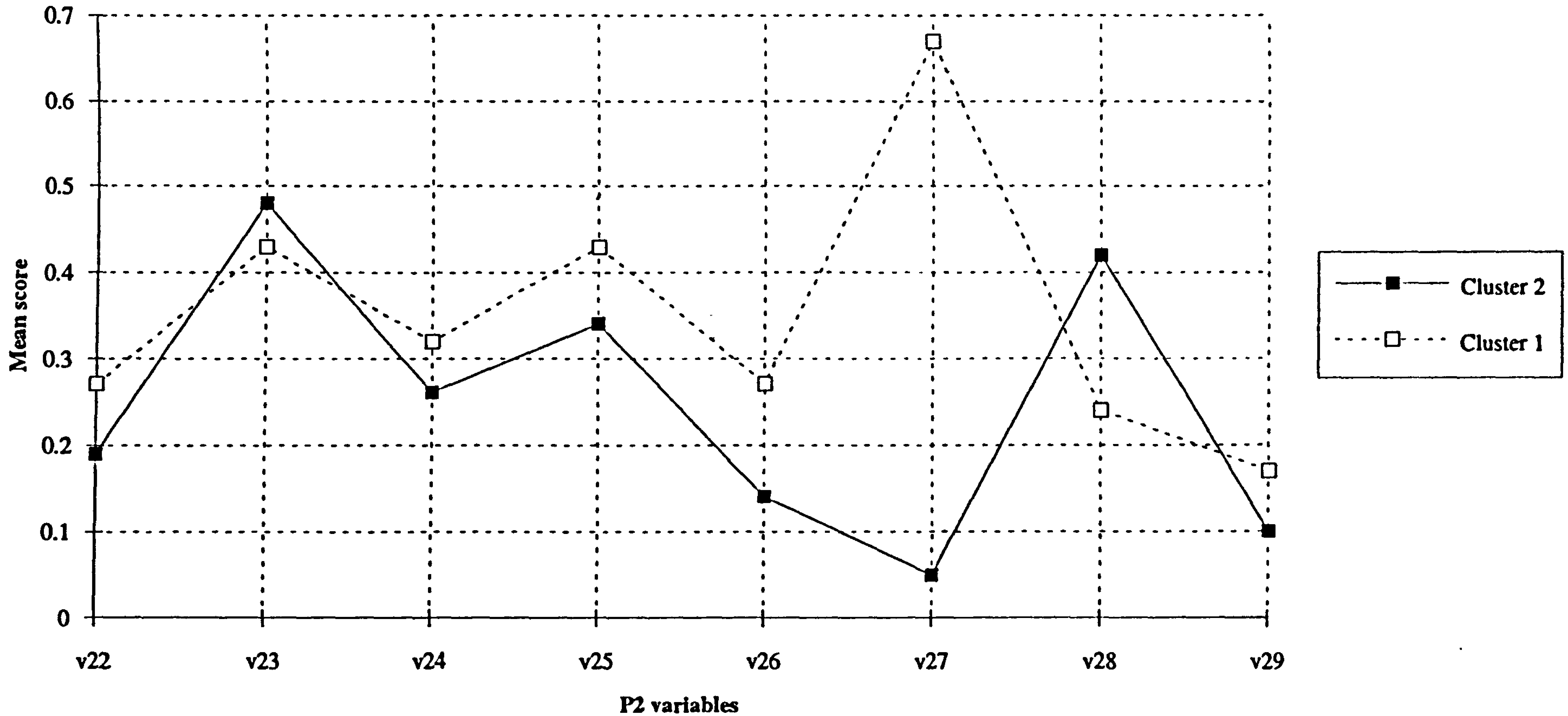


Table 8.32.
P2 data: analysis of variance (rationalised V_k score measures)

	Between		Within		Significance	
	df.	*SS*	*df.*	*SS*	*F*	*p.*
V22	1	0.028	20	0.010	2.64	0.120
V23	1	0.009	20	0.005	1.70	0.207
V24	1	0.013	20	0.011	1.20	0.285
V25	1	0.040	20	0.004	9.97	**0.005**
V26	1	0.089	20	0.021	4.20	**0.054**
V27	1	1.996	20	0.021	94.25	**0.000**
V28	1	0.157	20	0.041	3.77	0.066
V29	1	0.025	20	0.027	0.93	0.344

In conclusion, the cluster analysis exercise proved that the model outputs, particularly during P1 analysis, were able to correctly identify 'good' and 'not so good' contractors in the majority of cases.

8.6. FURTHER ANALYSIS OF CONTROLLING VARIABLES

From the previous analyses it has been established that the controlling variables (in distinguishing between 'good' and 'not so good' contractors) have performed as exhibited in Table 8.33.

The role of these statistically significant criteria was further investigated. Entire P1 data for case studies A to C were segregated by observing the C_s scores as described earlier (ie., $C_s > 5$ = 'good' contractor, $C_s \leq 5$ = NSG contractor).

Mean P1 V_i scores achieved amongst these sets were tested for difference using a t-test. That is, H_0: mean V score achieved for given variable by 'good' contractors is equal to the mean V score achieved for the same variable by NSG contractors. Therefore, H_a: the converse is true.

Table 8.33.
Controlling variables

P1 variables		P2 variables	
V_i measures	*Rationalised measures*	*V_k measures*	*Rationalised measures*
V1	V1	-	V22
V2	-	-	V23
V4*	-	-	V25
V5	-	-	V26
V8	V8	V27	V27
V9	V9	V28*	V28
V10	-	V29	V29
V11	V11		
V15	V15		
V19	V19		
-	V20		
V21	V21		

**significance 95% -remainder 99%*

Of all P1 criteria, 7 exhibited a significant difference. These 7 criteria, the mean score achieved in each for both sets, t-statistic and significance are shown in Table 8.34.

Table 8.34.
Significant prequalification variables:
mean score achieved between good and not-so-good contractors

Variable	Mean Good	S.D.	Mean NSG	S.D.	t-stat [a]	Signif.
V1: Size	0.80	0.42	0.29	0.49	2.32	0.035
V8: Bank ref'	0.56	0.33	0.11	0.13	3.35	0.004
V9: Credit refs'	0.82	0.14	0.24	0.25	6.14	0.000
V11: Qualif. owners	0.58	0.22	0.28	0.24	2.70	0.016
V19: Overruns time	0.67	0.28	0.29	0.33	2.60	0.020
V20: Overruns cost	0.62	0.33	0.22	0.16	2.94	0.010
V21: Overruns quality	0.73	0.25	0.27	0.24	3.85	0.002

[a] 17 observations, two sample means = 15 d.f. therefore $t_{0.025} = 2.131$.

The analysis showed that seven criteria exhibited a statistically significant higher score, achieved by the 'good' set of contractors. Referral to Table 8.30 confirms that these same seven criteria are included in the list of eight controlling variables (rationalised V_i score measures), identified during cluster analysis.

Notwithstanding there being difference between other mean scores (ie., amongst the remaining 14 criteria) the t-test confirmed that in these instances such differences *could* be attributable to chance.

Based on these results a multiple regression (MR) was performed of the seven significant criteria scores, amongst samples A to C, upon P1 scores achieved. This produced an equation of the form;

$\mathbf{P1} = 0.34 + 0.14_{V1} + 0.02_{V8} + 0.14_{V9} - 0.02_{V11} - 0.14_{V19} - 0.03_{V20} + 0.22_{V21}$

-coefficient of correlation 0.95, coefficient of determination 0.91. Observation of the residuals (Fig 8.21) for this regression shows that Cr11 is an outlier.

Removal of this outlier from the analysis produced an equation of the form;

$\mathbf{P1} = 0.316 + 0.16_{V1} + 0.02_{V8} + 0.20_{V9} - 0.065_{V11} - 0.15_{V19} - 0.04_{V20} + 0.22_{V21}$

thereby giving an improved coefficient of correlation 0.98 and coefficient of determination: 0.97.

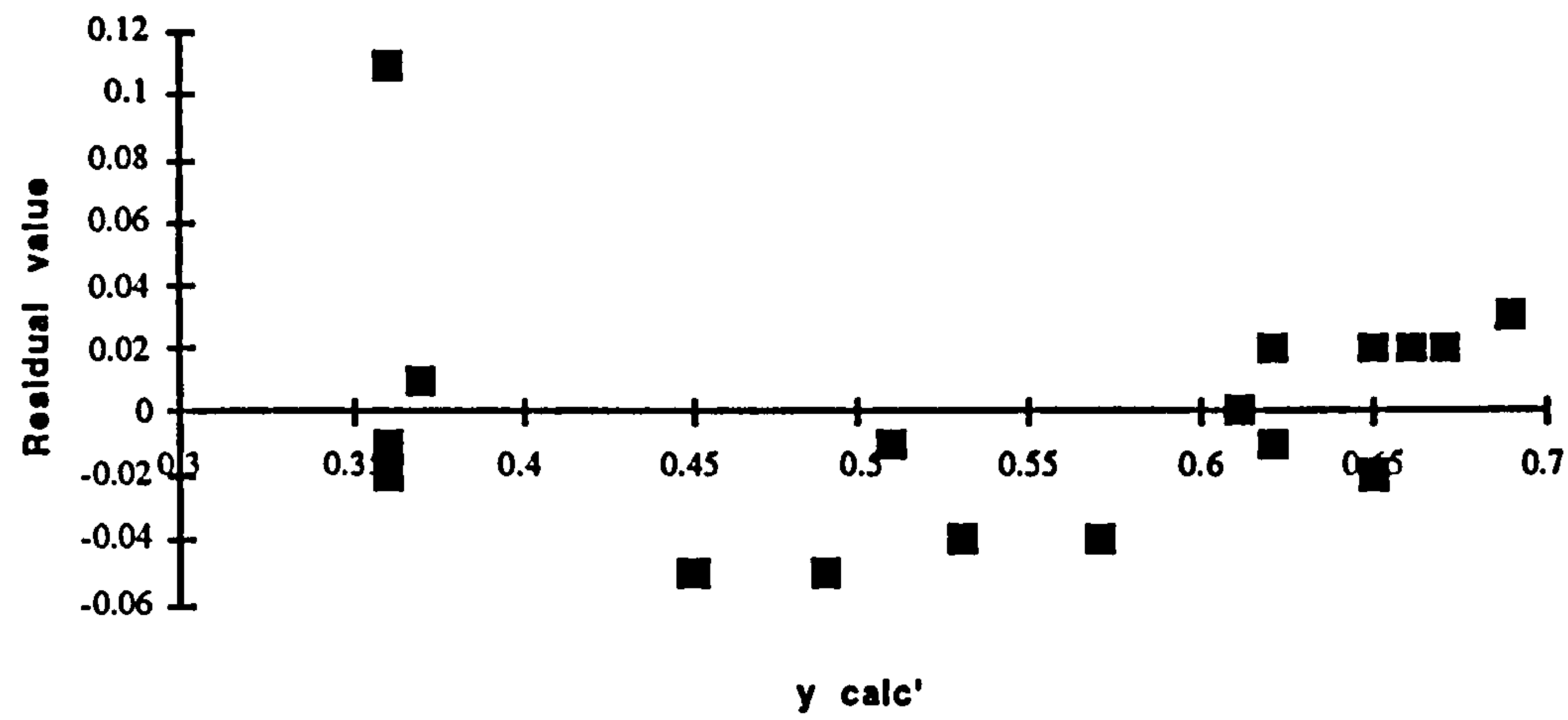
Presently, V11 is a function of turnover history and the variables: V19 to 21 (time, cost and quality performance). The latter three variables form part of the MR equation in themselves and therefore need not be considered twice. Hence, if V11 is removed from the analysis then we get;

$\mathbf{P1} = 0.311 + 0.151_{V1} + 0.035_{V8} + 0.154_{V9} - 0.159_{V19} - 0.031_{V20} + 0.232_{V21}$

Coefficient of correlation 0.983, coefficient of determination 0.967.

That is, 97% of movement in P1 is attributable to variation in the six V_i scores.

Figure 8.21.
Plot of residuals



Obviously, it is more than prudent to establish the financial stability of any contractor during prequalification. Therefore, if this was achieved using the measures highlighted earlier (ratio analysis, turnover history, ROCE and gearing) then combined with the MR approach, this would greatly rationalise the entire prequalification process.

Practically, evaluation might then take the form;

1. Is contractor financially stable? (Binary: yes / no) *if no reject;*
2. If answer is yes, then evaluate the six variables and produce P1 score for use in hierarchal ranking as previously employed in the model. Albeit the above contention is based on a relatively small sample, the exercise certainly intimates future potential for using MR in the contractor evaluation process. This is yet another facet of the subject area that could be investigated in future research.

8.7. SUMMARY

Most importantly, validation of the model has confirmed an ability to discriminate between 'good' and 'not so good' contractors. En-route to achieving this, it has been found *inter-alia*;

A formal contractor data collection document must be a prerequisite to any contractor taking part in the selection process.

Particular contractor attributes of concern, ie., those requiring close scrutiny, include current vacant workload, financial stability and quality control policy.

In terms of attribute evaluation, this work has shown that 'Good' contractors achieve a higher proportion of high attribute scores. 'Not so good' contractors achieve a higher proportion of low attribute scores, particularly in the class ≤ 0.30.

High bidders attain a higher proportion of high attribute scores, whilst low bidders achieve a more marked difference in those criteria of which they score highest.

The main determinants of 'good' and 'not so good' clusters during prequalification are;

- -V1: size of contractor (resources)
- -V8: bank reference
- -V9: credit references
- -V11: qualification of company owners
- -V15: experience -type of projects
- -V19: past performance -time overruns
- -V20: past performance -cost overruns
- -V21: past performance -quality achieved.

The main determinants of 'good' and 'not so good' clusters during tenderer evaluation are;

- -V25: key persons available for the project
- -V26: qualification of key personnel available for the project
- -V27: current workload capacity.

CHAPTER 9

THE CONTRACTORS' VIEW

9.0. INTRODUCTION

By way of contrast and conclusion to this research, this Chapter presents findings of a nationwide survey of UK construction *contractors*. The survey assessed their opinion of the Latham procurement recommendations, along with opinion of features pertaining to the alternative selection procedure developed in this thesis. With respect to the latter, this was presented as the H.O.L.T. (Highlight Optimum Legitimate Tender) selection technique. In general terms, contractors seem in tune with the ideals of the Latham review and characteristics pertaining to the H.O.L.T. selection method.

The chapter also identifies contractor usage / opinion of current tendering methods, tendering documentation and contractual arrangements.

9.1. THE LATHAM RECOMMENDATIONS REGARDING PROCUREMENT

As detailed early on in this thesis, the procedures around which contractors operate when competing for construction contracts has changed little for decades (Holt *et al*, 1993A; 1995A), the boldest exception being a transition from open tendering to more selective methods, brought about by Simon (1944) and subsequently reinforced by Banwell (1964) and the BEDC (1967).

Of late, a further transitional period has been evident with movement away from traditional 'designer led' projects towards package deal procurement (Harris & Sullivan, 1986; Holt *et al*, 1995A). This trend has seen contractors become more directly involved with the design and / or pure management of projects, in contrast to them being traditionally divorced from these functions.

Greater potential for change in the way contracts are procured, assigned and administered now emanates from recommendations of the recent Latham Review (Latham, 1994A). Some of the changes advocated by Latham include rationalisation of prequalification documentation, establishment of a central register ('approved 'select or 'standing' list) for all contractors seeking public sector work and, the introduction of quality ratings for such registered companies (Building, 1994; Latham 1993; Latham 1994A).

Indeed, the Construction Industry Board (formerly the Latham Review Implementation Forum) was established to effect these recommendations within set timescales. For example, producing a standard qualification form for public consultation by April 1995 and to publish a joint Code of Procedure for the selection of sub-contractors by January 1996 (Latham 1994B).

Particular characteristics of the H.O.L.T. technique underpin the Latham recommendations, in particular, the use of a standard prequalification document and evaluation procedure, the replacement of select lists with 'prequalification per project' and implementation of secondary, project specific evaluation to consider *tenderers* potential in respect of the proposed works (Holt *et al*, 1994D).

However, regardless of source, any changes introduced to replace or complement existing selection procedure would require endorsement by the industry -this includes contractors (the Constructors Liaison Group believes that recommendations of the Latham Review will not be implemented effectively unless they are underpinned by a Construction Contracts Act, see CLG, 1994). Without this consensus, would at best mean any such changes being difficult to operate successfully. At worst, change might generate resentment on the part of contractors at feeling coerced into a regime of which they do not approve.

These scenarios encapsulate the theme of this penultimate Chapter, that being, to present the results of a U.K. survey that investigated contractor opinion regarding the Latham review procurement recommendations, along with opinion of particular characteristics pertaining to the H.O.L.T. technique. The survey also facilitated the knowledge of *current* usage / contractor preference regarding: tendering arrangements, tendering documentation and contractual arrangements.

9.2. THE SURVEY SAMPLE

The main consideration during sample composition was to encompass a broad range of experienced, competent construction firms, active within the industry. The former was achieved by selecting contractors from the Chartered Institute of Building Directory (CIOB, 1994). By virtue of their chartered status these companies have successfully passed external audit, particularly in terms of staff / owner competency, chartered status and experience (CIOB, 1992). The latter was confirmed by targeting only those contractors indicating a previous year's turnover in excess of £1M.

The sample consisted of 106 construction companies. Each was approached by way of structured postal questionnaire, along with an accompanying letter explaining the purposes of the survey and why they had been invited to participate. A total of 44 responses were received (42 percent). Of these, 2 were incomplete and 1 was from a company who did not participate in tendering (speculative development only). The remaining 41 questionnaires represented 39 percent of the original sample. Table 9.1. details the sample composition and identifies respondents in terms of; company activity, catchment, previous years turnover and work types undertaken.

Table 9.1.
Contractor sample composition

Company activity	Nr.	%
Contractor	34	83
Contractor / developer	7	17
Other	nil	0
	41	100%

Geographical catchment	Nr.	%
Regional	35	85
National	5	13
International	1	2
	41	100%

Annual turnover (£M)	Nr.	%
>1 but ≤ 5	23	56
>5 but ≤ 10	6	15
>10	12	29
	41	100%

Work types [a] undertaken	%
Private contracts	49
Public contracts	41
Spec' development	6
Other [b]	4
	100%

[a] *Expressed as a percentage of the entire sample*

[b] *Despite the request to define 'other' the 4 percent failed to do so.*

It should be noted that this segregation (activity, catchment etc.) also applies to the remaining Tables in this Chapter, along with one further respondent: an international company. Albeit inferences cannot be drawn on one company alone (hence those results are not discussed in isolation), the response indicated 'International company' *has* been featured in the results, purely for comparison purposes.

Turnover per annum, is indicated in the Tables: ≤ £5M and > £5M (£5M being the median value amongst the sample). The majority of respondents described their work activity as contracting, with 17 percent also being involved with speculative development.

Regional firms were in the majority, with turnover amongst the sample ranging from a minimum of £1M to a maximum value of £650M per annum. Mean turnover value was £35M p.a. Percentage of work types undertaken ranged *from zero to*: 100 percent (private sector contracts), 95 percent (public sector contracts), 75 percent (speculative development) and 90 percent (other).

Table 9.1. also confirms that respondent's workload emanated predominantly from the private sector (mean percentage amongst sample 49 percent, mean percentage of public sector work undertaken 41 percent).

9.3. ANALYSIS AND DISCUSSION

Before a detailed discussion of the survey findings it is helpful to first understand the structure of the questionnaire employed which consisted of four parts: A, B, C & D. Part A sought general information to help segregate the data as exhibited in Table 9.1., along with percentage of tenders won by contractors (discussed below). Part B investigated trends in current tendering procedures / tendering documents and, contractual arrangements. Part C sought contractor opinion regarding potential for change to existing tendering / contractual procedures as advocated by the Latham Review. Finally, part D invited opinion of particular characteristics familiar to the H.O.L.T. evaluation / selection technique. A copy of the questionnaire is exhibited in Appendix P.

Current trends eg., usage, were examined by respondents indicating percentages of their total workload. For example, percentage of tenders won, percentage of worktypes undertaken, percentage of particular tendering documents used etc. Contractor preference, agreement and importance were measured by respondents indicating strength of opinion via numerical scaling. A scale of 1 to 5 was used where: 1 represented low strength and 5 represented maximum strength. This facilitated the derivation of preference, agreement and importance indices (Pr_i, Ag_i and Im_i respectively) via the formula;

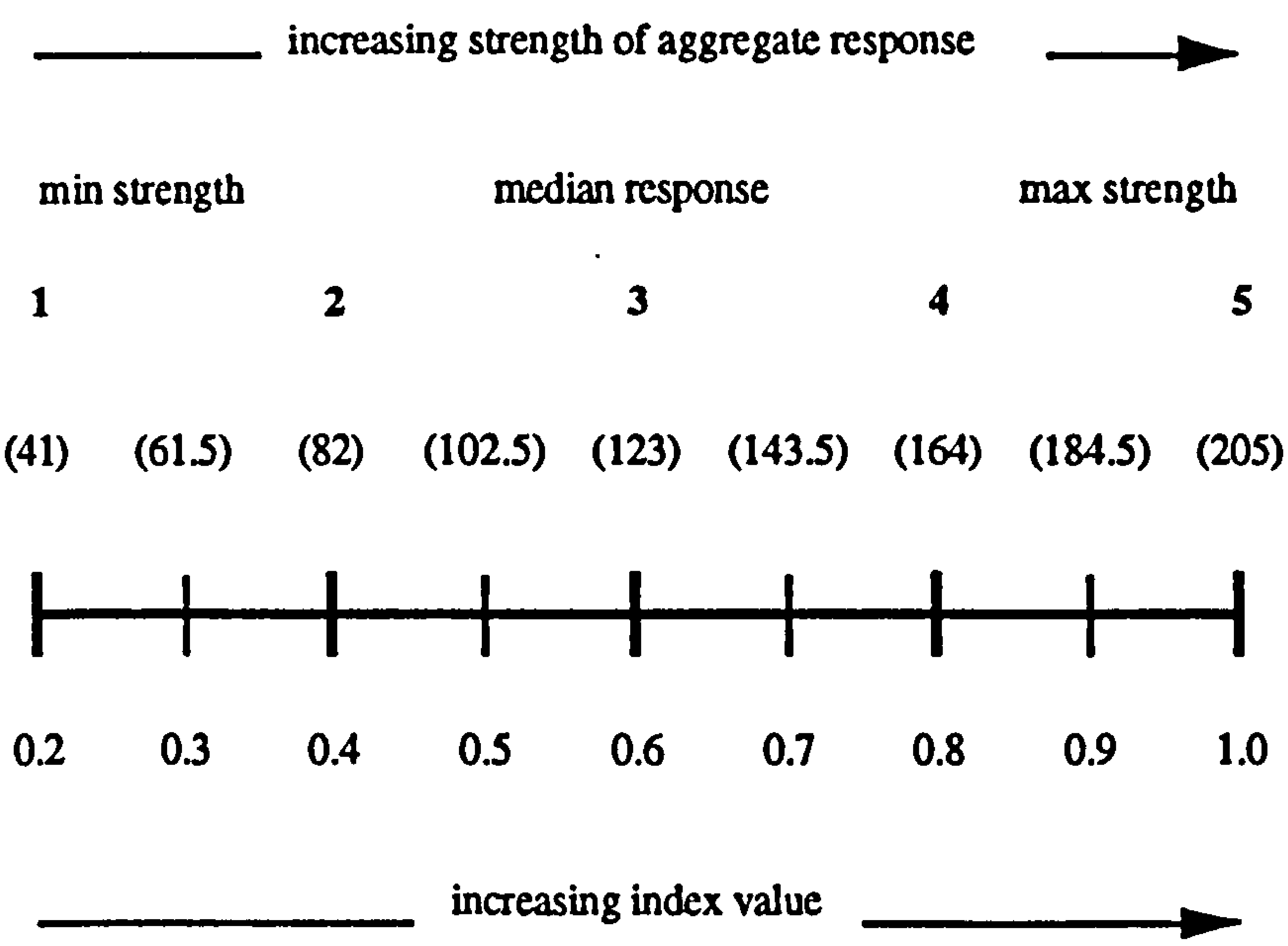
$$\textit{Index}_{ij} = \frac{1(n_1) + 2(n_2) + 3(n_3) + 4(n_4) + 5(n_5)}{5(n_1 + n_2 + n_3 + n_4 + n_5)}$$

where: $\textit{Index}_{ij}$ represents index i of variable j; 1,2,..,5 are the strength measures and n_1, n_2,...n_5 are the number of respondents that indicated these respective strength measures in respect of variable j (Bubshait & Al-Musaid, 1992; Kometa *et al*, 1995A).

For the type of data associated with this survey the mean and standard deviation may not be suitable statistics for ordering the variables (Shash, 1993), hence, the above relative index formula is frequently applied for this purpose (Olomolaiye, 1987; Bubshait & Al-Musaid, 1992; Shash, 1993; Holt et al, 1994C; Kometa et al, 1994; 1995A; 1995B).

The formula yields indices with a range of 0.8, where 0.2 represents minimum strength and 1.0 represents maximum strength, in each case. Figure 9.1. exhibits the transposition scale of aggregate survey response to respective index. Note that the scale is interval ie., no true zero, thereby giving an increase in strength of opinion a commensurate increase in $\textit{Index}_{ij}$.

Figure 9.1.
Transposition scale: aggregate survey response to *index*$_{ij}$



$$index_{ij} = \frac{\Sigma \text{responses variable } j}{5(\text{sample size})}$$

Figures in brackets show corresponding value of Σresponses in respect of the five integers shown and their midpoints, given the sample size of 41. Refer to text.

To demonstrate calculation of an agreement index, let us consider a variable attributable to the Latham recommendations. The questionnaire asked: "Indicate your level of agreement with the following statement where 1 = strongly disagree, 3 = undecided and 5 = strongly agree; *The public sector should cease devising their own prequalification questionnaires*." By substituting the survey response to this into the formula above, an index of 0.75 is determined, that is;

$$Ag_i = \frac{1(3)+2(6)+3(7)+4(8)+5(17)}{5(41)} = \frac{153}{205} = 0.75$$

Referral to Figure 9.1. confirms that contractors therefore have relatively strong agreement with this particular issue.

Where ties exist amongst resulting indices (eg., $Pr_{i(j)} = Pr_{i(k)}$ then ranking is possible by measuring the percentage of responses above the median value of the scale. That is, if aggregate response for $Pr_{i(j)}$ has more respondents scoring >3 on the strength scale than $Pri_{(k)}$ then $Pr_{i(j)}$ has a strength value > $Pr_{i(k)}$ (Shash, 1993; Kometa *et al*, 1994; 1995A).

Finally, an *overall* measure of preference, agreement or importance in respect of a given topic for each sample sub-group (refer Table 9.1.), may be determined by calculating the mean of all indices amongst that sub-group, in respect of all variables attributable to the topic (Kometa *et al*, 1995A). This is formalised by;

$$M_i = \frac{\sum_{k=1}^{n} \text{index for variable}_{ik}}{n}$$

where: M_i is the mean topic index and k are the n indices attributable to topic i.
For example, let us consider the overall measure of agreement for the topic: Latham recommendations, amongst the sub-group "contractors". Then;

$$MAg_i = \frac{\sum_{i=1}^{10} Ag_i}{10} = \frac{6.14}{10} = 0.61.$$

Referral to Figure 9.1. confirms that 0.61 represents a median response, that is, the sub-group 'contractors' are somewhat undecided in respect of this topic.

Having discussed the research tools and evaluation methodology, we may now investigate the survey response in a similar order to the questionnaire format.

9.3.1. Percentage of tenders won

Competition for work means that only one contractor of all those tendering for a project, will achieve contract award. The remainder will have expended resources for no direct return. Therefore, the percentage of contracts won by a company in relation to those tendered for, is important for two principal reasons;

i) 'wasted' expenditure eats into company profitability and hence the ability to remain buoyant;
ii) these fixed costs must be recovered and will therefore ultimately be paid for by the client (ie., via successful contract awards).

The latter has a direct influence upon construction costs generally. Initial results showed that contractors achieved contract award 25percent of the time (sample mean value, all contracts tendered for by number). To put it another way, the resources in compiling 75 percent of tenders are wasted but have to be paid for indirectly by construction clients.

The minimum percentage of contracts won was 8 percent, the maximum value 100 percent. The latter was a company whose workload consisted of 75 percent speculative development, the remainder being private sector contract work. If this apparent 'rogue' value of 100 percent is removed from the analysis then the mean value amongst all sample is 22.6 percent (standard deviation 14 percent).

In view of sample size (ie., n > 30) we may assume a normal distribution (Whitehead, 1984) therefore, 95 percent confidence limits for inferences on the *population* mean (μ) are: $\pm$ 1.96$\sigma/\sqrt{n}$ where σ = sample standard deviation and n = sample size (ibid). Hence, mean percentage of contracts won amongst the population should fall between $\pm$ 1.96(14)/$\sqrt{40}$ = $\pm$ 4.33. That is: (22.6 - 4.3) $\geq$ 18.3 percent and (22.6 + 4.3) $\leq$ 26.9 percent.

9.3.2. Tendering arrangements

Table 9.2 shows the percentages of tendering arrangements currently used by clients to obtain tenders.

Table 9.2.
Tendering arrangements used

	Percentage (%) usage					
Amongst;	Negot [a]	Open [b]	Select [c]	2-stage [d]	Serial [e]	Other [f]
All sample	**15.2**	**20.1**	**54.6**	**4.8**	**3.8**	**1.3**
Contractors	13.0	18.8	58.5	5.4	4.3	0.1
Contractors/developers	25.7	26.4	35.7	2.1	2.8	7.1
Regional companies	14.8	20.6	55.1	4.6	3.0	1.6
National companies	20.0	5.0	60.0	6.0	9.0	0.0
International company	5.0	75.0	10.0	5.0	5.0	0.0
Turnover >1M, ≤5M	16.4	20.8	52.7	3.3	4.1	2.3
Turnover >5M	13.7	19.1	57.0	6.6	3.4	0.0

[a]*Negotiation*
[b]*Open tender*
[c]*Selective tendering*
[d]*Two stage selective tendering*
[e]*Serial or continuity*
[f]*Other methods.*

It can be seen that selective competition is by far the most popular method (55 percent). The second most favoured arrangement is open competition (20 percent) - despite the methods' well known failings (Simon, 1944; Banwell, 1964; Latham, 1993; 94A). Negotiation accounts for only 15 percent, whilst the ability to bring on board a contractor early in the construction process via two stage selection, is largely ignored by clients (5 percent). The bringing together of those who have similar work in prospect is also little used (serial / continuity 4 percent).

The sub-group 'contractors' attain almost two thirds of their work via competition whilst companies with a 'national' spread obtain more work via negotiation. 'Contractors / developers' achieve most work via other means, these being indicated as design & build / direct order from client.

The respondents were asked of their preference for the different tendering arrangements discussed above. From their responses preference indices (Pr_i) were developed and these are exhibited in Table 9.3.

There is almost absolute preference for negotiation ($Pr_i = 1.0$), whilst the desire to take part in open tendering is marginal ($Pr_i = 0.26$). The former may prove an interesting point for debate primarily in light of Latham's contention for less adversarial relationships within the construction industry. Surely, if contractors find negotiation so desirable could not this predilection be better utilised to agree contract sum / conditions more often? So long as contractor accountability was taken account of then such an amicable approach might decrease the probability of adversity during the production phase.

The water has to some extent been tested in this area most notably the relationship between Bovis and Marks and Spencers (M&S) during the 1980's. M&S negotiated their contracts with Bovis the latter becoming project managers and remunerated with a percentage fee. At the turn of the 1990's M&S decided to revert back to competitive tender. However, this does not mean the approach didn't work. Rather, M&S felt that competition would achieve better value for money[1]. Clearly, there is scope for increased usage of negotiation, which may even incorporate an element of competition to placate the concerns of clients highlighted above. However, to convert negotiation into a dutch auction would be an abuse of the process.

Table 9.3.
Tendering arrangements preferred

	Preference index (Pr_i)					
Amongst;	Negot'	Open	Select	2 stage	Serial	Other
All sample	**1.00**	**0.26**	**0.74**	**0.61**	**0.69**	**0.80**
Contractors	0.99	0.24	0.76	0.61	0.69	0.60
Contractors/developers	1.00	0.34	0.63	0.60	0.69	0.90
Regional companies	0.99	0.25	0.75	0.61	0.66	0.00
National companies	1.00	0.32	0.64	0.60	0.88	0.00
International company	1.00	0.20	0.60	0.80	1.00	0.00
Turnover >1M, ≤ 5M	1.00	0.29	0.70	0.54	0.68	0.80
Turnover >5M	0.99	0.22	0.78	0.70	0.71	0.80

Contractor's obvious dislike for open tendering is logical for the reasons discussed earlier, but client's apparent inability to resist open competition (20 percent -refer Table 9.2.) is worrying in view of its failings. Contractors using 'other' methods seem most satisfied with such arrangements ($Pr_i = 0.8$), these being second only to negotiation.

[1] The previous paragraph is difficult to reference in that the information emanates from an individual with previous experience in the Bovis / M&S relationship. Anonymity has been respected.

9.3.3. Tendering documentation

It is apparent from Table 9.4. that drawings and specification are the most commonly used tender documents (53 percent amongst entire sample) with greatest usage amongst companies whose turnover ≤ £5M (67 percent).

Table 9.4.
Tendering documents used

	Percentage (%) usage			
Amongst;	Bills of quantity & drawings	Drawings & specification	Approximate bills of quantity	Other methods
All sample	**33.5**	**53.2**	**7.0**	**6.0**
Contractors	30.7	55.8	6.6	6.7
Contractors/developers	47.1	40.7	9.3	2.9
Regional companies	31.4	57.0	7.2	4.2
National companies	42.0	32.0	6.0	20.0
International company	65.0	30.0	5.0	0.0
Turnover >1M, ≤ 5M	23.9	67.3	5.6	3.0
Turnover >5M	45.8	35.2	8.8	10.0

These figures represent 30 percent increased usage over the last eight years when compared to the findings of Bresnen et al (1987). This would appear a function of client's attempting to save time and money during preparation of tenders. Indeed, drawing and specification negates the cost associated with Bill compilation and places greater risk on the contractor (eg., contractor has to conduct own take off prior to estimate).

This increase in use was borne out by comments made by respondents: "..there are not enough bills of quantity (BOQ) used..tender documentation is getting poorer particularly plan & specification..value of plan & specification tenders are getting increasingly higher" (see Appendix Q). BOQ's and drawings account for one third of tender documentation, with approximate bills representing only 7 percent.

Twenty five percent of respondents tendered on 'other' documents, such documents representing 6 percent usage amongst the sample. These other methods consisted: 25percent design & build documentation, with fixed cost and fee, schedule of rates, performance specification, client specification, cost plan / budget and, what was described as rubbish, all representing 12.5 percent each.

Amongst the sample as whole, BOQ's / drawings were most preferred ($Pr_i = 0.89$) followed by approximate bills then 'other' methods (Table 9.5). The former is understandable, BOQ's reduce possible errors during estimate build-up and any mistake in the Bill is indemnified by the client. The temptation to front end load Bills as a means of aiding cashflow will also be implicit to contractor estimators!

Drawings and specification were least favoured ($Pr_i = 0.59$) and bears a similar, important relationship to open tendering in the previous discussion, that is, contractors increasingly have to comply with procedures and documentation that they do not favour.

Table 9.5.
Tendering documents preferred

Amongst;	Preference index (Pri) BOQ's & drawings	Drawings & specification	Approximate bills of quantity	Other methods
All sample	**0.89**	**0.59**	**0.63**	**0.60**
Contractors	0.87	0.59	0.64	0.72
Contractors/developers	1.00	0.60	0.60	0.00
Regional companies	0.91	0.59	0.64	0.80
National companies	0.76	0.64	0.56	0.90
International company	1.00	0.40	0.80	0.00
Turnover >1M, ≤5M	0.91	0.61	0.62	0.75
Turnover >5M	0.87	0.57	0.66	0.70

9.3.4. Contractual arrangements

Table 9.6. shows that almost 70 percent of the sample are employed on what was described in the questionnaire as traditional JCT contracts (JCT, 1980; 1981; IFC, 1984). This may seem surprising in that the sum of management and design / build contracts account for only 23.4 percent. However, this statistic may be offset somewhat because respondents employed under the JCT design / build contract form (JCT, 1981) may have indicated "traditional JCT" on the questionnaire (ie., perceiving traditional to apply to JCT *contracts* as opposed to traditional designer led projects). Table 9.7. confirms that traditional JCT forms are favoured amongst contractors ($Pr_i = 0.82$) followed by design & build ($Pr_i = 0.71$) and management ($Pr_i = 0.49$).

Table 9.6.
Contractual arrangements used

Amongst;	Percentage (%) usage Traditional	Management	Design & build	Other
All sample	**69.8**	**3.9**	**19.5**	**6.8**
Contractors	72.6	4.4	16.2	7.0
Contractors/developers	56.4	1.4	35.7	6.4
Regional companies	72.1	1.0	19.0	8.0
National companies	55.0	24.0	21.0	0.0
International company	65.0	5.0	30.0	0.0
Turnover >1M, ≤5M	75.0	0.8	12.9	11.0
Turnover >5M	63.1	7.7	27.9	1.3

Table 9.7.
Contractual arrangements preferred

Amongst;	Preference index (Pr_i) Traditional	Management	Design & build	Other
All sample	**0.82**	**0.49**	**0.71**	**0.86**
Contractors	0.81	0.48	0.66	0.88
Contractors/developers	0.89	0.51	0.94	0.80
Regional companies	0.86	0.45	0.71	0.67
National companies	0.60	0.68	0.64	0.90
International company	0.80	0.80	1.00	0.00
Turnover >1M, ≤5M	0.84	0.41	0.62	0.85
Turnover >5M	0.80	0.59	0.82	0.90

Surprisingly, no contractors indicated usage or preference for the New Engineering Contract (NEC, 1993), however, this is a relatively new contract form. Despite Latham advocating its increased use clients appear to be wary of change.

Most satisfaction was expressed for other methods ($Pr_i = 0.86$). This 6.8 percent of the sample indicated such methods as being: clients own contract (50 percent), with written orders, contractors own contract and exchange of letters representing 16.6 percent each.

Having investigated current issues, opinion regarding potential for change may now be observed firstly, in light of Lathams recommendations and secondly, in context of the H.O.L.T. technique;

9.3.5. The Latham recommendations

The survey investigated strength of agreement regarding ten particular features of tendering / contractual issues, as advocated by the Latham review (Latham, 1994A), by asking respondents: "to what extent do you agree with the following recommendations". These are listed below. The bracketed letters adjacent each may be cross-referenced with Table 9.8;

(a): Dept. of Environment (DOE) should prepare a prequalification questionnaire for use by all contractors desirous of public sector work;

(b): public sector should cease devising their own prequalification questionnaires;

(c): the new questionnaires should be issued and received only by the DOE who would maintain a 'central' list of 'approved' contractors;

(d): only such 'approved' contractors should be invited to tender for Government commissioned work;

(e): there is no need for Local authorities, housing associations, educational establishments, NHS trusts, or health authorities to maintain their own list of contractors;

(f): local authorities, housing associations, educational establishments, NHS trusts, etc. should only use a 'National prequalification system' not their own system;

(g): a national system should also be a quality register related to contractor performance;

(h): a charge should be levied on 'approved' firms joining the central register

(i): sub-contractors hoping for public sector work should also be registered in a similar manner to that described above;

(j): contractors should as a condition of contract, only employ such registered sub-contract firms.

Agreement indices (Ag_i) were derived in respect of each feature as described earlier. These represented all sample and, sample sub-groups. Recommendation (a) achieved the highest index ($Ag_{i(a)} = 0.76$) confirming that a standard qualification document would be welcomed by contractors. This is reinforced by (b) achieving second rank ($Ag_{i(b)} = 0.75$) ie., that the public sector should cease devising their own questionnaires.

As one respondent pointed out: "present methods use poor documentation and cause us problems" (Appendix Q).

The recommendation that only 'approved' contractors should be invited to tender for Government commissioned work ranked third ($Ag_{i(d)} = 0.7$) above (g): a national system should also be a quality register and (c): standard questionnaires should be administered by the Department of the Environment (DOE). Jointly, they show agreement for the DOE to administer an approved list, this serving also as a 'quality register' reflecting contractor performance. (Albeit recommendations (c) and (g) achieved the same index of 0.68, the latter ranks highest with 52 percent of responses above the median value of 3 on the strength scale. The former had 48 percent of similar responses).

Table 9.8.
Agreement indices: Latham recommendations

	Agreement index (Ag_i) per recommendation*										
Amongst;	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	*MAg_i*
All sample	**0.76**	**0.75**	**0.68**	**0.70**	**0.52**	**0.63**	**0.68**	**0.31**	**0.54**	**0.44**	***0.60***
Contractors	0.78	0.78	0.68	0.74	0.52	0.63	0.72	0.31	0.54	0.44	*0.61*
Contract/developers	0.66	0.60	0.69	0.54	0.51	0.63	0.51	0.29	0.54	0.43	*0.55*
Regional companies	0.75	0.75	0.66	0.71	0.50	0.59	0.67	0.30	0.54	0.43	*0.59*
National companies	0.76	0.72	0.84	0.68	0.64	0.88	0.76	0.40	0.56	0.52	*0.67*
International company	0.80	0.60	0.60	0.60	0.40	0.80	0.80	0.20	0.40	0.40	*0.56*
Turnover >1M, ≤5M	0.71	0.71	0.67	0.65	0.55	0.62	0.70	0.32	0.51	0.39	*0.58*
Turnover >5M	0.91	0.79	0.70	0.77	0.48	0.64	0.67	0.29	0.58	0.50	*0.63*
Agreement ranks†	**1**	**2**	**5††**	**3**	**8**	**6**	**4††**	**10**	**7**	**9**	

** The letters (a) to (j) correspond with the recommendations listed in the text*
† Based on aggregate response
†† Based on percentage response above median value on strength scale

The contention that a national prequalification system should take precedence over any other system achieved an index: $Ag_{i(f)} = 0.63$. This result when viewed with the above and the mild agreement that sub-contractors should be registered in a similar manner ($Ag_{i(i)} = 0.54$) would seem to indicate that contractors are far from satisfied with the bespoke selection / tender procedures currently in use.

The lowest agreement index confirmed that contractors do not desire to contribute financially towards any changes in procedure ($Ag_{i(n)} = 0.31$). Second lowest index would indicate that potential constraints (ie., *which* sub-contractors may be employed by main contractors) would not be welcomed either ($Ag_{i(j)} = 0.44$).

Observation of sub-set indices yield some interesting inequalities. Contractors with a large turnover feel most strongly that the DOE should produce a standard qualification document ($Ag_i = 0.91$). Contractors / developers are least in favour of i) the public sector devising their own questionnaires and ii) only inviting DOE approved contractors to tender for government commissioned work. Larger companies feel exactly opposite regarding these two specific recommendations. Larger companies are also most in favour of registered sub-contractors (and only employing the same) whilst smaller contractors are most strongly against such registration.

Finally, the last column of Table 9.8. exhibits the mean agreement indices (MAg_i) for each sample sub group determined from the formula elucidated earlier. These mean values should be viewed in the context that there will be some overlap between the sub groups. However, despite minimal dispersion they show strongest overall agreement for the Latham recommendations amongst 'National' companies ($MAg_i = 0.67$) and weakest strength of agreement amongst contractors / developers ($MAg_i = 0.55$).

9.3.6. The H.O.L.T. selection technique

"The H.O.L.T. selection methodology serves to meet the contractor selection requirements of the Latham review panel, with a three stage approach to contractor selection" (EPSRC, 1994).

"Many features of the technique catch the spirit of the times along the theme of evolving contractual relationships" (McCaffer, 1994).

Below are listed nine specific features of the method, that were presented to contractors. The bracketed letters adjacent each feature may be cross-referenced with Table 9.9;

- (a): select' 'approved' or 'standing' lists are not used;
- (b): all contractors desirous to tender are prequalified per project;
- (c): all contractors invited to tender are further evaluated, in view of project specific criteria ie., their potential to satisfactorily execute the project being tendered for;
- (d): the method uses a standard set of selection criteria at all times;
- (e): the selection criteria could be made known to contractors;
- (f): the method could offer feedback to 'unsuccessful' contractors;
- (g): a 'score' is computed for each contractor evaluated;
- (h): the above score could be made available to all contractors evaluated;
- (j): if adopted by the industry as a whole a 'standard' procedure would prevail.

Contractors were asked what level of importance they attribute to these particular characteristics, the response from which was derived importance indices Im_j, for the sample as a whole and, sample sub-groups.

Most importance was attributed to the feature: prequalification criteria could be made known to contractors ($Im_{j(e)} = 0.93$). Based on this, the pessimist might contend that contractors will only address those particular areas evaluated, to improve chances of success during prequalification. The optimist might feel that anything to encourage contractors to take a closer look at what they have to offer the client, will nurture improvement amongst contractor companies and hence, quality of output, generally.

The importance of feedback to unsuccessful contractors ranked second ($Im_{i(f)}$ = 0.89). This compares with the findings of Hartman (1994), in that feedback rated amongst the top four factors that contractors consider, when deciding which jobs to tender for.

Table 9.9.
Importance indices: the H.O.L.T. selection method

	Importance index (Im_i)*									
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(j)	MIm_i
Amongst;										
All sample	**0.58**	**0.74**	**0.80**	**0.76**	**0.93**	**0.89**	**0.71**	**0.78**	**0.72**	***0.76***
Contractors	0.56	0.77	0.80	0.78	0.93	0.89	0.72	0.76	0.72	*0.77*
Contractors/developers	0.69	0.60	0.80	0.69	0.91	0.89	0.66	0.86	0.71	*0.75*
Regional companies	0.58	0.74	0.80	0.76	0.93	0.89	0.72	0.77	0.70	*0.76*
National companies	0.64	0.84	0.88	0.76	0.92	0.92	0.64	0.84	0.84	*0.80*
International company	0.40	0.40	0.40	0.80	0.80	0.80	0.60	0.80	0.80	*0.64*
Turnover >1M, ≤5M	0.63	0.79	0.83	0.79	0.91	0.90	0.64	0.73	0.72	*0.77*
Turnover >5M	0.52	0.68	0.76	0.72	0.94	0.88	0.79	0.83	0.71	*0.75*
Importance ranks†	**9**	**6**	**3**	**5**	**1**	**2**	**8**	**4**	**7**	

* *The letters (a) to (j) correspond with the recommendations listed in the text*
† *Based on aggregate response.*

Could this not be capitalised upon? Any system that promoted constructive feedback to unsuccessful tenderers would encourage firms to address their identified areas of weakness and therefore, be of benefit to the industry as a whole.

That tenderers are subject to secondary, more specific evaluation (c), that an overall score computed for each tenderer during evaluation could be made known to them (h) and, that a standard set of prequalification criteria are used (d), ranked 3rd, 4th and 5th respectively.

The former would indicate that contractors do not mind thorough evaluation, arguably, good contractors would feel confident in taking part in such. Indeed, as one respondent commented: "Any system that eliminates rogue contractors is welcome" (Appendix Q). Companies being made aware of their score relates to 'feedback' -discussed above.

Lowest overall importance was attributed to the feature: select lists are not used ($Im_{i(a)} = 0.58$). Perhaps this is a function of contractors feeling secure when on a select list ie., increased probability of invitations to tender: "..once on a select list we get repeat enquiries" (Appendix Q).

Indices amongst the sub sets show that national companies attribute strongest importance to prequalification per project and, further secondary evaluation of *tenderers*. Contractors / developers attribute least importance to the computation of an evaluation score, whilst national companies by far attribute most importance to the possibility of a standard procedure prevailing. The latter would reflect that national companies have to partake in varying selection procedures: "there is a great need for standardisation..current procedures are a mess" (Appendix Q).

Observation of mean importance indices (MIm_i) show strongest feelings of importance amongst national contractors ($M\text{Im}_i$ = 0.80) with weakest strength amongst contractors / developers whose turnover is ≥ £5M ($M\text{Im}_i$ = 0.75).

Overall, the relatively high importance indices are encouraging (≥ 0.58), that is, contractors generally appear in favour of the H.O.L.T. characteristics presented to them.

9.4. SUMMARY

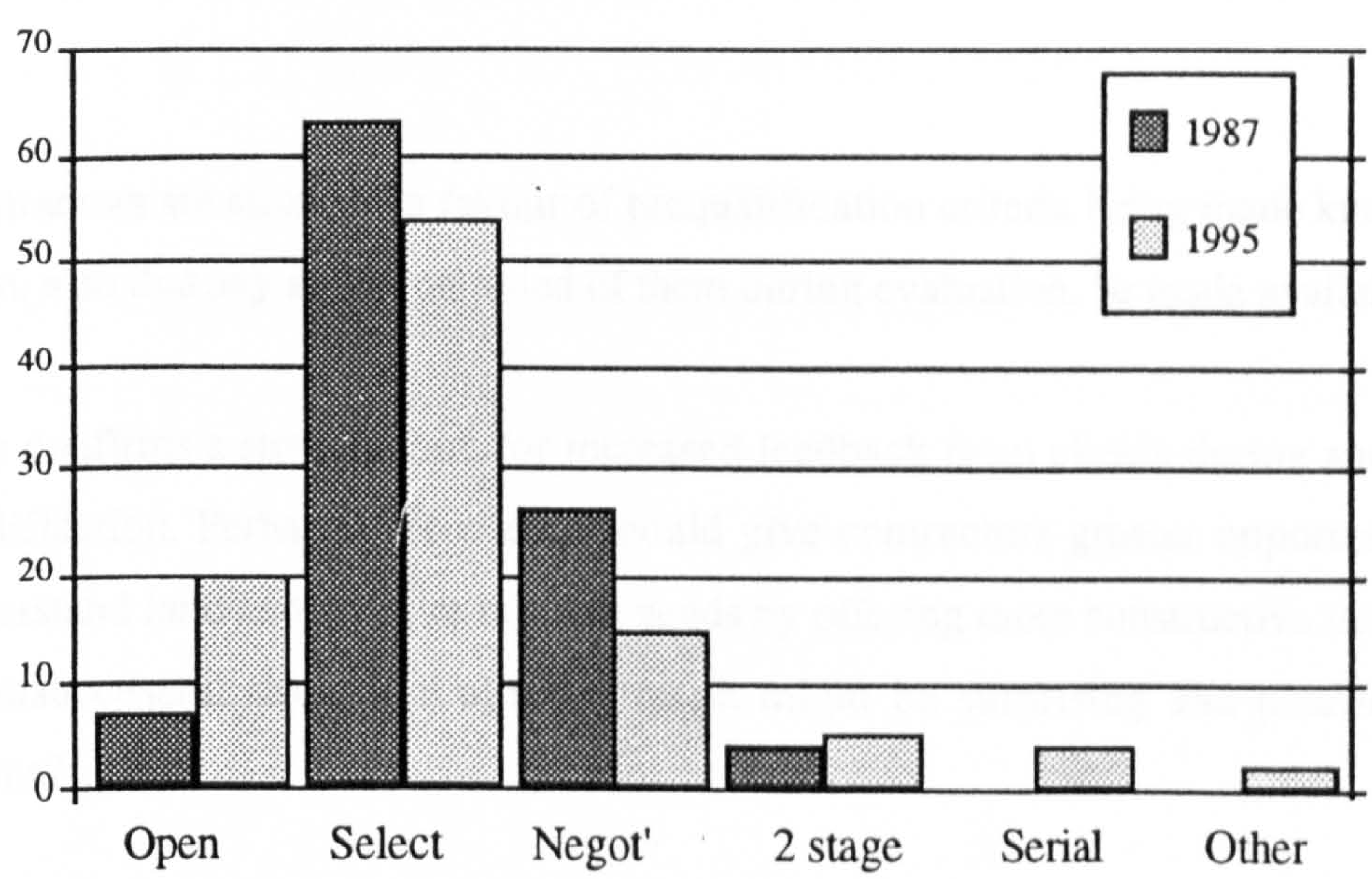
The survey confirmed that contractors achieve contract award only once in approximately every five tenders submitted. This means that clients must ultimately pay for the costs expended on the remaining 80 percent of tenders compiled. When considered jointly with the fact that open methods currently account for 20 percent of tendering arrangements, it seems that clients are overlooking the real issues of procurement costs. That is, open methods might very well encourage lower bid levels, but the higher proportion of wasted resources that these methods create, offset any potential savings.

Clients should reduce open tendering if the target of 30 percent reduction in real construction costs advocated by Latham (1994A) are to be achieved. Perhaps contractor predilection for negotiation could be taken into account in this objective?

The survey also highlighted increased use of plan and specification but more worryingly, for projects of increasing value. As one respondent commented: "Unfortunately, due to financial pressures more and more tenders are being put out on plan and specification which is causing massive wasted effort and cost on the part of unsuccessful tenderers". This result can be seen graphically, along with comparison of the survey findings in relation to tendering trends of 1987 (Bresnen et al., 1987), in Figures 9.2. & 9.3.

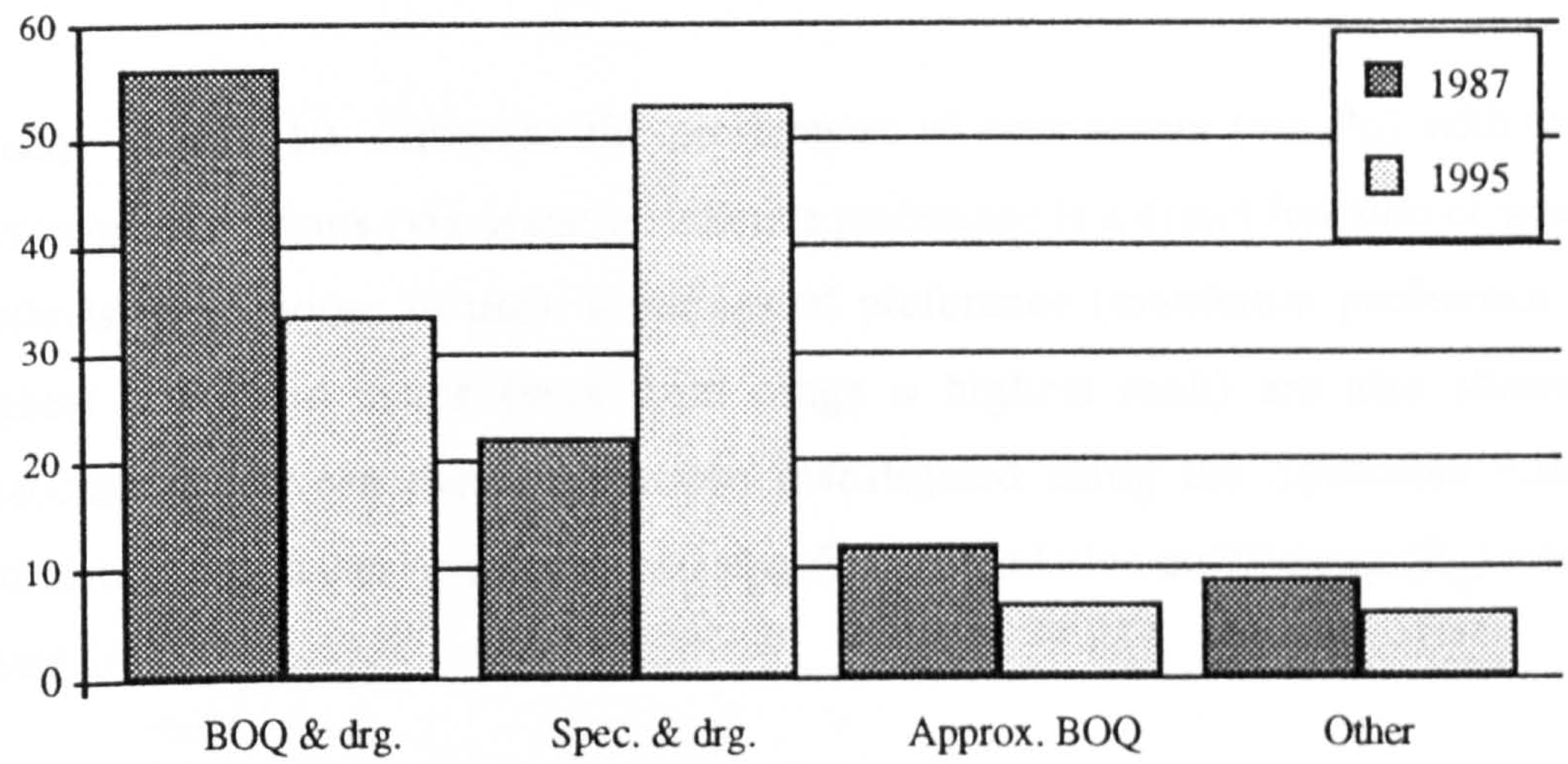
Regarding the Latham Review, strongest agreement was for a standard qualification document and, for the public sector to cease devising their own questionnaires. Combined with the agreement that a national system should take precedence over current bespoke systems, confirms dissatisfaction with present methods generally. However, contractors do not want constraints such as with whom they may sub-contract nor, do they wish to contribute financially to any proposed changes. Perhaps the latter is understandable in view of recent market forces: "companies are -still tendering at up to 10 percent below cost in order to obtain work" (Appendix Q).

Figure 9.2.
Comparison of tendering trends: percentages



The 1987 percentages are after Bresnen et al, (1987).

Figure 9.3.
Comparison of tendering documentation: percentages



The 1987 percentages are after Bresnen et al, (1987).

Contractors are strongly in favour of prequalification criteria being made known to them, also that any score computed of them during evaluation, be made available.

This confirms a strong desire for increased feedback from clients during and after qualification. Perhaps here clients should give contractors greater opportunity to understand (and hence aspire to) their needs by offering more constructive feedback to unsuccessful firms -the ultimate result might be surprising and pleasing for clients?

The H.O.L.T. technique features characteristics in sympathy with the Latham recommendations and the standardisation of tendering procedure that contractors apparently seek. This is reflected in the high importance indices attributed the characteristics presented (H.O.L.T. $MIm_i = 0.76$). Not only does the technique offer scope for standardisation, but further, implements a formal evaluation / score / feedback structure to give contractors the opportunity discussed above.

Finally, Table 9.10. compares the preferences of contractors (via Pr_i) with the preferences of clients (via usage ie., client's preference is a direct function of what methods they choose to use). Rankings of preference (maximum preference = highest rank) and usage (maximum usage = highest rank) are also shown. Association between these ranks was investigated using the Spearman Rank Correlation test. It can be seen that no significant correlation coefficients (R_s) were found.

Therefore, we may deduce that this lack of consensus (client / practitioner preference) means that contractors are not satisfied with many aspects of current procurement procedure. Indeed, from the comments in Appendix Q, clearly contractors would welcome any improvements to existing procedure with enthusiasm.

This should be encouraging to the authors of *Constructing The Team* (Latham 1994A) and is satisfying to the writer, who has advocated such for the past three years.

Table 9. 10.
Summary rank analysis: usage vis-a-vis preference

	Usage ie., Client Preference		Contractor preference	
	%	**Rank**	**Pri**	**Rank**
Tendering arrangements:				
Negotiation	15.2	3	1.00	1
Open tender	20.1	2	0.26	6
Selective tendering	54.6	1	0.74	3
Two stage selective tendering	4.8	4	0.61	5
Serial or continuity	3.8	5	0.69	4
Other methods	1.3	6	0.80	2
			(R_s = -0.20 signif. 0.70)	
Tendering documentation:				
BOQ's / drawings	33.5	2	0.89	1
Drawings / specification	53.2	1	0.59	4
Approximate BOQ's	7.0	3	0.63	2
Other	6.0	4	0.60	3
			(R_s = -0.20 signif. 0.80)	
Contractual arrangements:				
Traditional (JCT)	69.8	1	0.82	2
Management	3.9	4	0.49	4
Design and build	19.5	2	0.71	3
Other	6.8	3	0.86	1
			(R_s = 0.40 signif. 0.60)	

CHAPTER 10

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

10.1. CONCLUSIONS

Regardless of procurement route, project nature or tendering procedure employed, the construction owner will ultimately need to select a contractor in whom can be entrusted the project (Holt et al, 1995B). This decision directly impacts project outcome in terms of time, cost and quality achieved (Holt et al, 1994B). Hence, it is one of the most important decisions a client has to make (Odusote, 1990; Russell et al, 1990).

Selection may be broadly classified as being competitive or revolving around negotiation (cf. Franks, 1990). However, these distinctions are prone to variance - the final process utilised may be a combination of both (Holt et al, 1995A).

Pre 1950, projects were typically designer led and assigned via open competition (Burrows, 1991). Since that time the industry has witnessed significant changes in the way contracts are procured and assigned (Brook, 1993). Following the shift away from open to more selective methods initiated by Simon (1944), there has recently been a growth in package deal procurement and 'management' type contracts (Sullivan & Harris, 1986; Holt et al, 1995A).

Notwithstanding change, the first paragraph of this summary holds true and therefore underpins the theme of this research.

Clients are the key to construction, since they fund it, their needs should be paramount (Latham, 1993), but existing selection methods tend to overlook this objective (Holt et al, 1993A; 1993B; 1995A). Client satisfaction (time, cost and quality) is a function of contractor suitability (Russell & Skibniewski, 1988; Russell et al, 1992; Holt et al, 1994B). However, cost often dominates the selection decision at times to the exclusion of suitability (Hartman, 1993).

The failings of present day selection methods may be expressed under four heads (Holt et al, 1995A);

a) *Lack of a universal approach* -notwithstanding an abundance of Codes, Procedures and Recommendations (N.J.C.C., various; I.C.E., 1980; F.I.D.I.C., 1982; C.I.C., 1994) selection practice remains fragmented. Subsequently, selection expertise varies considerably from organisation to organisation (Holt et al, 1993C).

b) *Long term confidence attributed to preselection* -many owners erroneously express long-term confidence in the corporate stability of contractors based solely on prequalification (Merna & Smith, 1990; Holt et al, 1995B). Prequalification should form an essential component of any selection exercise, but not simply be a prerequisite to a standing list. Prequalification should establish corporate stability / performance potential *just prior* to final selection.

c) *Final selection and tender evaluation methods* -ultimate choice is dominated by acceptance of lowest bid (Merna & Smith, 1990). Investigation of tenderers, should examine contractor performance potential with respect to the *proposed project* (cf. Russell, 1992) -in tandem with bid value (Holt et al, 1995B).

d) *Reliance on subjective analysis* -traditional techniques rely on subjectivity.

Presently, practitioners are left with little alternative to subjective judgment and experience.

These weaknesses justified the need for revision of existing tender / selection procedure. Therefore, this research developed and tested an alternative selection model, encompassing the following stages:

a) identification of selection criteria;
b) derivation of an algorithmic model;
c) identification of criteria evaluation methods;
d) hypothetical application of the model;
e) real - life application of the model.

10.1.1. Identification of selection criteria

The model was based on the philosophy of comparing choices to performance criteria. These criteria were determined via;

a) observing relevant literature;
b) structured survey of practitioners and clients; this also facilitated the knowledge of respective levels of importance for each criterion identified.

The literature review;

c) identified criteria necessary for consideration during contractor selection;
d) identified contractor attributes worthy of investigation when evaluating the potential performance of firms;
e) utilised (c) and (d) to compile a structured questionnaire for the above survey (b).

By observing the number of times that each criterion was commended as being necessary for inclusion in the process amongst the literature, a rating was assigned to each. Based on this rating the top five ranking were;

1. Non - specific financial analysis
2. Experience - size of projects
3. Experience - non specific
4. Experience - type of projects
5. Contractors current workload.

Although indicative, the ranking exercise was viewed with caution because the sample size was limited, and no quantitative levels of importance had been previously assigned to the criteria by authors. To further 'sort' the criteria they were grouped into clusters of like nature *viz*;

a) organisational criteria (21 variables);
b) past performance criteria (12 variables);
c) past experience criteria (6 variables);
d) financial criteria (7 variables);
e) other criteria (3 variables).

A subsequent national survey of both public and private sector practitioners and clients was undertaken to *confirm* what criteria should be included in the model and, levels of importance attributable to each.

From the survey data, a total of 29 criteria were identified and weighted in terms of importance. Based on the weightings, the top five ranking were;

1. Contractors workload capacity

2. Past experience -size of projects completed
3. Management resource -existence of a formal training regime
4. National or local catchment of the contractor
5. Experience -type of projects completed.

The 29 variables were subsequently grouped into Prequalification criteria and Secondary investigative criteria. The former apply to all contractors desirous to tender, the second to tenderers only.

Each generic classification consisted of sub-classifications, these being designated as factors. Each factor consisted groups of like variables. The factors were;

Prequalification factors;

a) Contractors organisation (6 criteria);
b) Financial considerations (4 criteria);
c) Management resources (4 criteria);
d) Past experience (3 criteria);
e) Past performance (4 criteria).

Secondary investigative factors;

f) Project specific (5 criteria);
g) Other specific (3 criteria).

In *general* terms, the survey found that resource availability and previous experience related criteria, ranked highest.

10.1.2. Derivation of an algorithmic model

The model was a decision making tool, as characterised by there being more than one course of action (Kaufman & Thomas, 1977; Skitmore 1989), the core of the problem being rational evaluation. That is, evaluation of the available set was made difficult by the interaction of client objectives and contractor attributes (cf. Diekmann, 1979). The most suitable solution was identified as multi-attribute analysis (MAA), this being optimal because;

a) it is a quantitative approach;
b) it facilitates consideration of multiple attributes;
c) options may be rated against client objectives (criteria);
d) preferences may be incorporated by assigning weights.

The inclusion of utility (cf. Hwang & Yoon, 1981) took account of client preferences, thereby influencing selection outcome ie., to best mirror client objectives.

A stepwise logic of the entire selection process was determined to serve as a framework for the model. Eleven essential steps were identified;

1. identify selection criteria;
2. identify contractors desirous to tender;
3. gather prequalification data;
4. evaluate contractors and establish a shortlist;
5. invite tenders from (4);
6. gather secondary investigative data from tenderers;
7. apply tenderer data to project specific criteria;
8. evaluate results and establish an hierarchal list;
9. evaluate the bid component of tenders;
10. combine (8) and (9) to establish a final ranking;
11. choose contractor -which (all other things being equal) will be highest rank under (10).

A three tier process encapsulated the above, upon which the model was finalised;

Stage 1. Prequalification of contractors	(steps 1 to 4 above);
Stage 2. Evaluation of tenderers	(steps 5 to 9);
Stage 3. Final selection choice	(steps 10 & 11).

Numerical output of the model is representative of contractor potential for project performance. That is, better attributes = higher criterion scores = higher overall score = greater performance potential. It was logical therefore to classify the overall score from each of the three components above as *potential performance* (P) scores;

Stage 1 prequalification potential:	P1 score;
Stage 2 project specific potential:	P2 score;
Stage 3 *overall* time, cost and quality potential:	P3 score.

10.1.3. Identification of criteria evaluation methods

Modes of investigation for each criterion were rationalised into a standardised set of operations. This was achieved by in depth investigation of relevant literature, previous research and liaison with practitioners. Hence, each criterion could be scored (V score) where $0 \leq V \leq 1.0$.

This conversion of criteria natural units (£, number of years, yes/no, etc.) to an interval scale, facilitated integration of such commensurate values into the model. Thus an aggregated measure could be computed in respect of both; prequalification criteria (Holt et al, 1994A) and tenderer (project specific) criteria (Holt et al, 1994C).

10.1.4. Hypothetical application of the model

The developed technique was fully elucidated showing that the comprehensive model output facilitated thorough investigation of contractors via;

a) V scores achieved (contractor characteristics in respect of each selection criterion);
b) factor scores produced (contractor characteristics in respect of each factor - thereby avoiding a firm with an acceptable overall score but, a particular weakness, from slipping through the net);
c) P scores (allowing ordinal sorting of all firms during prequalification, tender evaluation and, ultimately highlighting optimum choice).

The exercise confirmed that it is not necessarily the lowest bidder that achieves highest overall (P3) score but rather, the firm exhibiting the most all round performance potential (time, cost and quality parameters).

10.1.5. Real life application of the model

Association between differing contractor attributes and understanding of contractor organisational relationships were enhanced by application to real life selection exercises. Model ability to discriminate and ultimately classify 'good' and 'not so good' firms was confirmed by applying the statistical technique of cluster analysis.

Rudimentary observations amongst contractors evaluated, identified *inter-alia*;

a) Questionable financial capacity in respect of the project being tendered for.
b) A lack of BS 5750 certification or intention to apply for such.
c) Negative trends in financial measures (current ratio, interest cover and turnover).
d) That half of management staff did not hold a degree, but half of all managers did have chartered status.
e) All contractors had previous experience akin to the contract being tendered

for.

f) Ninety three percent of firms had previously executed a project within a 25 mile radius of the proposed project.

Investigation of association between attribute (V) scores achieved, identified several correlating features;

a) Size of company and health & safety regime: larger firms are more probable to commit adequate resources to health & safety of their employees.
b) Size of company & increasing turnover: younger firms ardently pursue growth in their formative years.
c) Age of company and experience -size of projects: mature companies have greater probability of having executed larger projects whilst the converse is also true.
d) Satisfactory credit references and experience -size of projects.
e) Increasing turnover and an adequate training regime.
f) Increasing turnover and avoiding too large projects for the firm's resources.
g) Previous poor (contractor / client) relationship and adequate proposed management structure for the proposed project.

Further analysis of all variable scores achieved, identified that;

a) A maximum score was achieved on at least one occasion, in all variables except: ratio analysis of accounts, credit references and bank reference mirroring financial fragility of contractors at this time.
b) No maximum score was achieved regarding qualification of company owners; but owners fared better than key personnel. The latter achieved a low mean score indicating that more training / education is called for.

Based on the mean of V scores achieved, the top five (best) scoring were;

1. Failure to have completed a contract (m= 1.0);
2. Experience - type of projects (m=0.93);
3. Experience - size of projects (m=0.83);
4. Age of company (m=0.82);
5. Health and safety policy (m=0.74)

The three lowest mean V scores were;

1. National/local catchment (m=0.16);
2. Qualification of key persons (m=0.21);
3. Quality control policy (m=0.21).

In general terms, the mean values achieved amongst tenderer evaluation criteria were higher than those achieved during prequalification. This is logical in that there is less disparity amongst the latter set once prequalification has been performed.

Segregation of the sample into 'good' and 'not so good' contractors identified *inter-alia* that in general terms 'good' contractors exhibited;

a) broad experience - type of projects;
b) having traded for at least 3 years;
c) broad experience - size of projects;
d) a satisfactory health and safety record;
e) a good company image

'not so good' contractors;

a) were younger companies;

b) with poor bank references;

c) with poor credit references;

d) and were local to the proposed project.

Further that;

a) In terms of prequalification criteria, amongst the entire sample, 'good' contractors achieved a maximum score ≥ corresponding maximum scores for not-so-good contractors in every criterion.

b) Mean attribute scores obtained by 'good' contractors were ≥ those for 'not so good' contractors 67 percent of the time.

In respect of all criteria, highest mean scores were split 60 percent 'good' contractors and 40 percent 'not so good' contractors. The model distinguished 'good' contractors most particularly during prequalification. Had the sample contained 'bad' contractors we can reasonably assume that those differences would have been more pronounced.

Cumulative proportion analysis revealed that 'good' contractors exhibit a greater proportion of mean V scores in the classes ≥ 0.90 with no mean scores in the class ≤ 0.15. 'Not so good' contractors exhibit a greater proportion of lower attribute scores particularly below the boundary 0.30, and reduced proportion of higher attributes scores particularly above the boundary 0.90.

Segregation of the sample into high / low bidders identified that;

a) High bidders achieved a higher V score in 42 percent of P1 variables with low bidders being higher 38 percent of the time.

b) Regarding P2 variables, again there was less disparity between the sets with a greater degree of variance amongst high bidders.

Cumulative proportion analysis showed that high bidders achieved a greater proportion of higher attribute scores. Low bidders exhibited the converse. Overall, high bidders had;

a) adequate resources for the project;
b) an adequate Health and Safety policy;
c) witnessed minimum time overruns (previous projects);
d) had adequate spare workload capacity.

Low bidders performed better in terms of;

a) age (older companies);
b) image;
c) geographic experience.

As an acid test as to whether the model could truly classify contractors, the pooled model output data were subjected to cluster analysis (cf. Everitt, 1980). By using V scores as measures in the analysis (ie., P1 data) two principal clusters were naturally inherent within the data with all but two of the 'good' contractors correctly classified.

From observation of the final cluster centres, ten controlling variables were identified (significant at the 99% level);

V1: size of contractor (resources);
V2: age of the company;

V5: health & safety policy;

V8: bank reference;

V9: credit references;

V10: turnover history;

V11: qualification of company owners;

V15: experience -type of projects;

V19: past performance -time overruns;

V21: past performance -quality achieved.

By using V_k scores as measures (ie., P2 data) again two clusters were formed. Cluster 1 was predominantly 'not so good' contractors and cluster 2 predominantly 'good' contractors. Observation of the final cluster centres, confirmed the controlling variables were;

V27: current workload capacity;

V28: previous client relationship;

V29: home office location to project.

These results were excellent in that based on V scores, the model clearly distinguishes between 'good' and 'not so good' contractors.

A similar analysis was performed using rationalised V scores ie., raw V scores multiplied by relevant weightings and (in the case of P2 criteria) utility values.

In terms of prequalification, the analysis was more accurate than previous with all but one case correctly assigned to 'good' / 'not so good' sets. In the case of rationalised V_i scores the controlling variables were;

V1: size of contractor (resources);

V8: bank reference;

V9: credit references;

V11: qualification of company owners;

V15: experience -type of projects;

V19: past performance -time overruns;

V20: past performance -cost overruns;

V21: past performance -quality achieved;

-each significant at the 99% level.

In summary, the results of cluster analysis were significant, particularly the latter examination as this proved that by utilising the criteria weighting coefficients, a more reliable outcome is ascertained.

As a conclusion to the research, a survey of selected UK contracting companies was performed. This determined *inter-alia* opinion of potential for change to present procedure, as advocated by both Latham and this research.

Regarding the Latham procurement recommendations, strongest agreement was for a standard prequalification document and for the public sector to cease devising their own questionnaires. This combined with agreement that a 'National" system should take precedence over bespoke systems, confirms general dissatisfaction amongst contractors with present methods.

There was also found to be strong agreement for the characteristics of the H.O.L.T. selection method, particularly the features of;

-the potential for a standard procedure prevailing;

-greater potential for feedback during and after contractor evaluation.

Contractors indicated the latter to be most important and could be capitalised upon - any selection procedure yielding comprehensive feedback to "unsuccessful" firms would encourage those firms to address their areas of weakness. This could only be of benefit to the industry as a whole -both contracting companies and clients alike.

10.2. RECOMMENDATIONS & FURTHER RESEARCH

The process of contractor selection needs to be standardised, as initially indicated by this research (Holt et al, 1993A; B) and confirmed by the recommendations of the Latham review (Latham 1994A).

Notwithstanding the above, there will always be sectors of the industry that require bespoke selection procedures because of their specific function. For example, the nuclear sector which requires high levels of security and contractor integrity.

To date this alternative selection model has concentrated upon the traditional designer / client led, lump sum procurement option coupled with single stage selection. Obviously a variation in procurement route might mean greater or lesser importance attributed to the criteria within the model, or the inclusion of further criteria eg., *ability of contractors internal design team* for design and build.

In a similar vein, the criteria importance coefficients are based on survey of industry practitioners and client groups. However, the dynamic nature of construction means that such emphases must change with time. Hence, for both the above reasons, future or even cyclical survey of clients / practitioners may be required.

Regarding the model outputs, these can only be as reliable as the raw contractor data input. In the first instance this means that financial evaluation albeit based upon audited accounts is a 'snapshot in time' and such accounts are only properly updated annually. Despite avid attempts to quantify this aspect, perhaps here lies an area that to a lesser extent has to rely upon practitioner experience and maybe financial searches in cases of concern.

Secondly, the need for reliable, representative contractor attribute information has confirmed that tender analysis cannot be properly performed without full completion of the data collection questionnaires by contractors. As such, these must be made a prerequisite of contractor's taking part in any formal selection exercise.

The encouraging results presented are to be built upon by application to much larger samples encompassing variations in client / project types and sizes. Several clients both in the public and private sectors, have embraced the technique and should collaborate in this longer term aim.

Comparison of model output with contractor ability has utilised a scoring mechanism of 1 to 10 for each superlative client objective: time, cost and quality. In future this should be done on a scale of 1 to 100 thereby facilitating greater differentiation by the client. For example a difference may not be perceptible between 6 and 7 but is more probable to be so between 60 and 70.

Furthermore, contractor analysis in this thesis has considered primarily, contractor ability based upon past (project) performance. This was possible because the client was familiar with each company. Future research need necessarily also consider *actual project performance* ie., how did model rating for the firm compare to project outturn?

Analysis has confirmed that greater weight needs to be attributed to contractor performance potential than to tender sum. This reinforces the contention of many authors, the most recent being Latham. Further analyses should investigate the lower weighting attributable to tender sum identified in this work.

Regardless of selection method or criteria applied, *results* of attribute evaluation ultimately influence the contractor selection decision. Current codes of procedure only intimate areas worthy of investigation. Modes of evaluation, which criteria to apply and levels of attainment to be achieved by contractors for such criteria remain at practitioners' discretion. The research theme should continue in earnest, if the Latham recommendations regarding rationalisation of contractor selection and procurement in general, are to be achieved.

It has been shown that contractors are prepared to distort facts somewhat, if that will enhance their portfolio and hence increase their chances during evaluation. Further research could be directed towards development of a retrospective contractor data collection / validation data base. This would not only highlight anomalies in tender submissions, but assist during evaluation in terms of identifying trends etc.

The cluster analysis technique exhibits broader, future potential than has been exploited herein. The technique could be applied to the original set (contractors desirous to tender), not only to identify good / not so good firms, but further, taxons containing contractors of (say) specialist nature, able to undertake works of specific size (cf. current select lists) or for particular classes of project.

In conclusion, this research has contributed significantly to the aura of construction procurement, lean supply and client objectives, that has germinated over the last few years and will continue to grow for the foreseeable future.

However, the fundamental theme of contractors exhibiting minimum standards, as set out in this work, should never be overlooked.

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Appendix A

Letter from collaborating client

TERRY OAKES C Eng, DISTRICT TECHNICAL AND LEISURE SERVICES OFFICER
Mariners Street
Lowestoft Suffolk NR32 1JT
Telephone (01502) 562111
Fax (01502) 514617 DX 41220

WAVENEY DISTRICT COUNCIL

Technical and Leisure Services Department

Your Ref
Our Ref RA/TJC 400/12/03
Date 31 January 1995

When calling please ask for Mr. R. Ayres
Dial Direct (01502) 523391

FIRST CLASS MAIL

School of Construction, Engineering & Technology,
University of Wolverhampton,
Wulfruna Street,
WOLVERHAMPTON. WV1 1SB

For the attention of Mr. Gary Holt

Dear Sir,

Contractor Selection

Thank you for your letter ref. VAL/WAV dated 11 January 1995 together with the enclosed performance rating questionnaire.

Happy New Year to you also. Things here are much the same, excepting that the delay in my reply to your letter is attributable to pressure of work in preparing contract documents for a four year measured term contract.

Your work to date has been extremely useful, as the answers to the questionnaire confirm. However, in selection of contractors one must not be naive to agendas of employers, policy makers, senior officers and their reaction to external matters such as social or political reaction, but I am sure you have considered this important factor.

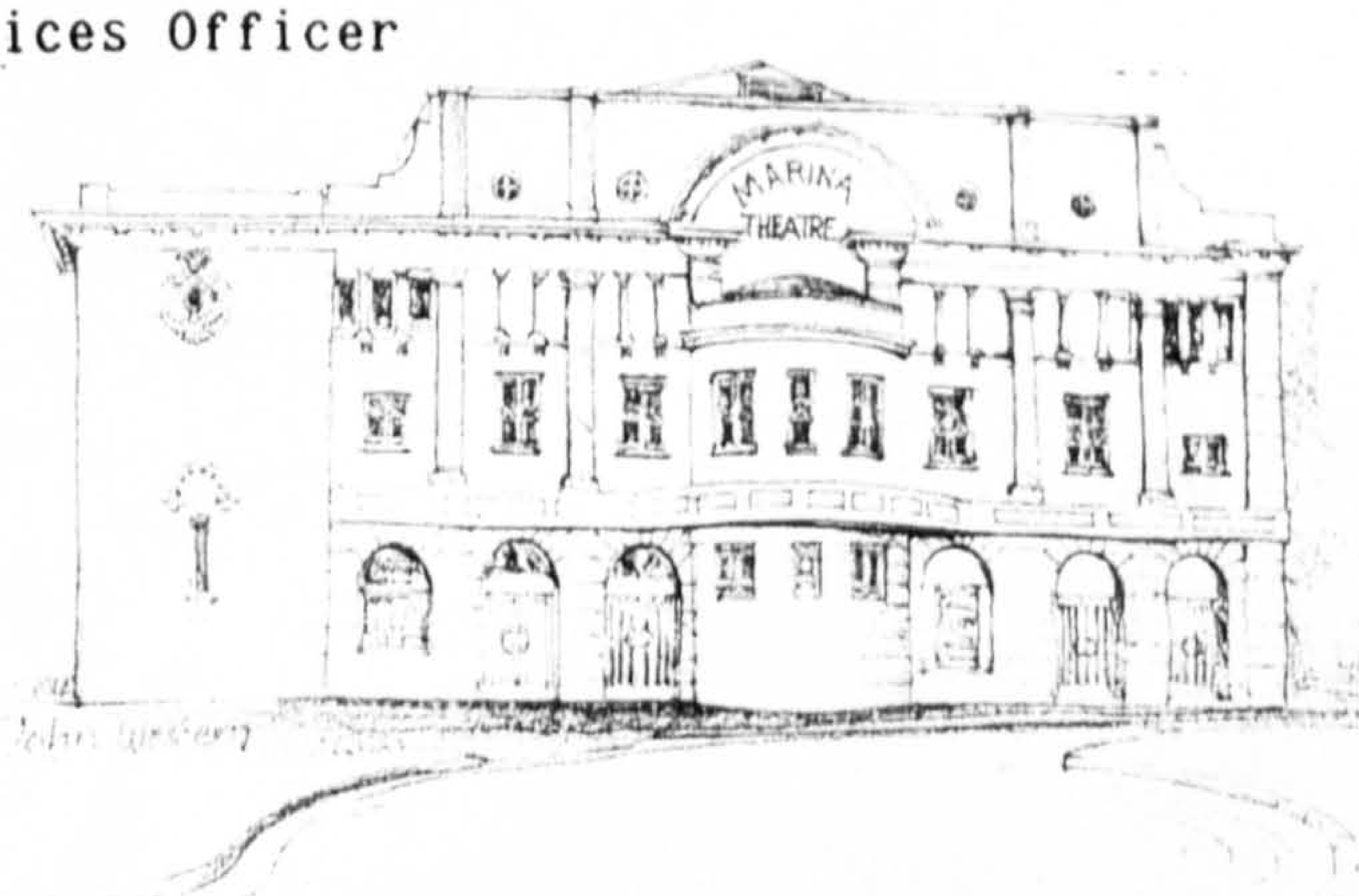
My feelings about the research are positive. My previous selection technique was based on financial evaluation, qualification of managers and staff historical performance etc. and my selection would have been much the same as your results. I am constrained politically and therefore some lists would contain contractors I would not otherwise choose, personally.

I look forward to receipt of any of your work and should I be able to assist further I would be pleased to do so.

Yours faithfully,

Chief Architectural Services Officer
for District Technical & Leisure Services Officer

Enc.



Appendix B

Letter re: Latham review

Department of the Environment

Room P1/078
2 Marsham Street
London SW1P 3EB

Direct Line: 071 276 0645
Fax: 071 276 3826

Mr G D Holt
Lecturer
School of Construction and Engineering
Technology
University of Wolverhampton
Wulfruna Street
Wolverhampton
WV1 1SB

9 February 1994

Dear Mr Holt

Thank you for your letter of 20 January about the Review by Sir Michael Latham of the procurement and contracting arrangements in the UK construction industry.

I found the comments contained in your letter and the summary of your research of the development of a model for predicting the performance potential of construction of contractors extremely interesting and have passed copies of both on to Sir Michael Latham. I am very grateful to you for writing and may contact you again once I have discussed your comments with Sir Michael.

Yours sincerely

Deborah Bronnert

Appendix C

Letter re: Construction Industry Board

CONSTRUCTION INDUSTRY BOARD

The Building Centre, 26 Store Street, London WC1E 7BT

Chairman Sir Michael Latham

Malcolm Dodds	071 636 2254
Richard Mellish	071 636 2256
Facsimile	071 580 6137

Mr G D Holt
University of Wolverhampton
Wulfruna Street
Wolverhampton
WV1 1SB

16 March 1995

Dear Mr Holt

WORKING GROUP 5: INTRODUCTION OF A STANDARD QUALIFICATION DOCUMENT FOR PUBLIC SECTOR WORK AND DEVELOPMENT OF CMIS

Thank you very much for your letter of 13 February addressed to the Review Implementation Forum. I am sorry for the delay in responding but one of the reasons for this is that the Forum has now become the Construction Industry Board and we have been busy making the necessary arrangements. I attach three recent News Releases that explain the position we have currently reached.

It does certainly seem that the work on contractor selection that you have been undertaking as part of your research programme chimes very much with that being carried out by our Working Group 5. One slight difference of emphasis is that it is our Working Group 4, which is looking at the selection of consultants, that has in fact spent more time looking at how quality as well as price can be taken into account in selection mechanisms.

I am copying your letter and the enclosures to Colin Garton who, by happy coincidence, acts as secretary to both Working Groups 4 and 5. I am sure Colin will be in touch if he feels that there is scope for further interaction between either of the Groups and your University, but if you need to contact him he can be reached on 071 276 0460 at the Department of Environment.

Can I also request sight, if possible, of the results of your survey when they are available? This would be much appreciated.

Thank you once again for writing.

Yours sincerely

Richard Mellish

RICHARD MELLISH

Appendix D

Survey (criteria) questionnaire

SURVEY QUESTIONNAIRE
[PUBLIC SECTOR]

The competitive tendering process is a popular method of contractor selection, but discriminates in the main on the price component - time and quality being difficult to quantify at this point. Hence the aim of this research project, is to devise a quantitative method of predicting contractor performance at the pre-selection and tender evaluation stages.

The questionnaire consists of 3 parts;

Part 1: Invites brief information about your Department for data classification purposes.

Part 2: Analyses factors that you might consider to preselect a contractor, (ie, for a tender list) as competent to perform the work if awarded a construction contract.

Part 3: Analyses factors that you might consider when evaluating a contractor, ie., after tender submission.

Your Departments' opinion is sought as to the importance of each factor, and its frequency as being the fundamental cause of your dissatisfaction with a contractor/s performance over the last two years.

All Information will be treated in the strictest confidence and will be used only for the purpose of academic endeavour.

THANK YOU FOR YOUR ATTENTION.

PART 1.

Q1. Name of Authority..

Q2. Head Office..

....

Q3.Department..Tel:..............................

Q4. Nature of business..

Q5. Total building work your department has awarded to contractors over the last 2 years;

a. Value £.. b. No' of projects..

Q6. Tick which one of the following, most represents how satisfied you are with building contractors' performance for you over the last 2 years,

( ) Totally satisfied ( ) Just satisfied ( ) Totally dissatisfied

Q7. Tick which point on the scale below best represents the effectiveness of your contractor selection process over the last 2 years.
where : 1 = Totally effective , 5 = ineffective.

totally effective		satisfactory		ineffective
( )1.	( )2.	( )3.	( )4.	( )5.

Q8. Designation of person completing questionnaire..

INSTRUCTIONS FOR PARTS 2 & 3.

In column A. please circle a number to rank each factor a level of importance where;
3 = critically important 2 = of some importance 1 = no importance whatsoever

In column B. If a factor has been the fundamental cause of your dissatisfaction with a contractors performance during the last two years - please insert how many times.

Example: Say you consider "size of the organisation" to be critically important and this factor has caused your dissatisfaction with a contractor 4 times over the last 2 years then;

8.1. Size 1............2............3 ....4.........

If you consider a factor irrelevant please strike it through. If you wish to add further factors please do so in the spaces provided - then rank and number them in the same way.

PART 2: PRE-SELECTION FACTORS.

	Column A - *how important?* (no importance / some importance / critically important)	Column B *how often?*
Q8. Contractors Organisation		
8.1. Size	1..............2..............3	....
8.2. Age	1..............2..............3	....
8.3. Corporate image	1..............2..............3	....
8.4. Quality control policy	1..............2..............3	....
8.5. Health and safety policy	1..............2..............3	....
8.6. Litigation tendency	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....

Column A - *how important?* Column B *how often?*

	no importance	some importance	critically important	
Q9. Pre-selection Financial Implications;				
9.1. Ratio analysis of accounts	1	2	3	....
9.2. Bank reference	1	2	3	....
9.3. Credit references	1	2	3	....
9.4. Turnover history	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
10. Contractors Management Resource;				
10.1. Qualification: owners	1	2	3	....
10.2. Qualification: key personnel	1	2	3	....
10.3. Years with firm: key persons	1	2	3	....
10.4. Formal training regime	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
11. General Past Experience;				
11.1 Type of projects completed	1	2	3	....
11.2. Size of projects completed	1	2	3	....
11.3. National or local	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
12. Past Performance;				
12.1. Failure to have completed a contract	1	2	3	....
12.2. Contracts overrun: time	1	2	3	....
12.3. Contracts overrun: cost	1	2	3	....
12.4. Actual quality achieved	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....
....	1	2	3	....

PART 3: TENDER EVALUATION FACTORS. *- if your current procedure does not consider any further factors ie., if pre-selection factors in Part 1 are satisfied, then choice would now be made on tender price please tick: ( ), however, even if this is the case please complete columns A & B below as before, in the context of: what importance would you attach to the following factors as a means of assisting your current evaluation process?*

	Column A - *how important?* (no importance / some importance / critically important)	Column B *how often?*
13. Project Related Specific;		
13.1. Past experience geographically	1..............2..............3	....
13.2. Experience of a similar construction	1..............2..............3	....
13.3. Plant resource available for project	1..............2..............3	....
13.4. Key persons available for project	1..............2..............3	....
13.5.Qualification of these key persons	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
14. Other More Specific Factors;		
14.1. Current workload	1..............2..............3	....
14.2. Prior relationship with L.Authority	1..............2..............3	....
14.3. Home office location to project	1..............2..............3	....
14.5. Time of year - weather	1..............2..............3	....
14.6 Form of contract	1..............2..............3	....
Any other (specify);		
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....
....	1..............2..............3	....

Should you wish to add any further comments please do so on the rear of this page. Your co-operation in this matter is most appreciated - please tick below if you would like to receive a summary of the research conclusions. tick: ( )

Please forward completed questionnaire to;

Mr. G.D.Holt
University of Wolverhampton
School of Construction and Engineering Technology
Wulfruna Street
Wolverhampton
WV1 1SB

Thank you

Appendix E

Sample public sector questionnaire

TENDERING QUESTIONNAIRE

(Based on the Model Tendering Questionnaire agreed by the local authority Associations and the National Federation of Building Trade's Employers)

CONFIDENTIAL

SECTION A

To be completed by the Local Authority

1. Name of Local Authority:	Council
2. Relevant Department, its address and telephone number:	
3. Local Authority Reference:	

Contracts are subject to Standing Orders of the Council and particular attention is drawn to the following requirement:-

> Every contract that exceeds £20,000 in value or amount and is for the execution of works shall provide for some pecuniary penalty as liquidated damages and the Council shall take security equal to 10% of the value or amount of the contract.

SECTION B

The questions set out hereafter are to be completed by firms wishing to be included on the above mentioned Local Authority's tendering list. applicants are asked to note that they may be required to provide information regarding their financial position, in the form of a further questionnaire, when the Local Authority are considering inviting tenders for a particular job.

4. Name of Firm:

5. Registered Office Address:

6. (a) Local Office Address and Telephone No.:

(b) Addresses of other factories and workshops or offices:

7. Person dealing with this application on the firm's behalf:

Name: Telephone No.:

8. Date of formation or registration: Registration No. where limited company:

State whether Public or Private

Please note: Consideration will only be given to firms who have been trading for more than three years.

9. (a) If a member of a group of companies, give the names and addresses of the ultimate Parent Company and any other subsidiaries involved in building construction or associated fields in England or Wales. Please include on additional page(s).

(b) Would the Group or Parent Company guarantee the contract performance of its subsidiary where it is wholly owned?

10. (a) Brief description of company business:

(b) Please confirm that the objects of the company, as stated in its memorandum of association, cover the purposes for which this list is being compiled.

11. Full names and address of the directors, or the partners, and the Secretary: If more than five, attach separate sheet.

12. Nominal and paid up share capital:

13. Name and Address of Insurane Brokers:

14. Employers liability Insurances:

Insurer: Address:

Policy No.:

Expiry Date: Branch No.:

Amount of Cover:

15. Public Liability (Third Party) Insurances:

Insurer: Address:

Policy No.:

Expiry Date:

Amount of Cover: Branch No.:

16. Indicate the turnover during each of the last 5 years.

17. Please complete with details of the highest value contract undertaken during the past three years, preferably for Local Authority Clients in each of the following categories where you wish to be considered for submitting tenders for work.

Type of Work	Value	Completion Date	Client & a Contact Name & Address
Building Construction New Work.			
Building Construction: Alterations & Improvements			
Mechanical Services			
Electrical Services			
Painting & Decorating			
Stone Restoration			
Demolition and Site Clearance			
Asbestos Removal			
Roofing and Cladding			
Damp Proofing and Preservation/ Timber Treatment			

18. Please complete the following information, where appropriate, for the type of work for which you wish to be invited to tender.		
Type of Work	Up to £150,000	over £150,000 Please indicate maximum value
C1. Building Construction: New Works		
C3. Building Construction: Alterations & Improvements		
C5. Mechanical Services		
C7. Electrical Services		
C9. Painting & Decorating		
C11. Stone Restoration		
C13. Demolition and Site Clearance		
C15. Asbestos Removal		
C17. Roofing and Cladding		
C19. Damp Proofing and Preservation/Timber Treatment		

19. Name and address of Bank:

Account Name:

Account Number:

20. State the approximate number of employees employed on a regular basis under the following headings:

(a) Administrative and Clerical Staff

(b) Technical Staff

(c) Operatives

21. (a) How many management trainees do you have?

(b) How many apprentices do you have?

(c) What is the average proportion of apprentices to craftsmen?

22. What trades do you usually subcontract?

23. Are you a member of any recognised trade association? If so, please specify:

24. Does your company comply with the Wages Act 1986?

25. Give names and addresses of three Referees (two of which should be local authorities or equivalent) from whom reference may be sought:

(a)

(b)

(c)

26. Please give any other comments that may be of assistance to the Authority in considering this application:

I/We hereby apply for inclusion in the selective Tendering List for building work in the categories indicated in 18 above.

Signed ....

Position ....

For and on behalf of ....

Date..

Appendix F

P1 analysis sheets

PREQUALIFICATION (P1) ANALYSIS SHEETS

NB.

✎ = descriptive insertion required by practitioner.
✍ = numeric insertion required by practitioner

V1 Size
(A) Approx. maximum required financial commitment by contractor to proposed project = 2 x [contract sum/contract period(months)].
(B) Approx. contractor capacity = (current assets - current liabilities + one half non-current assets[exc. goodwill] - non-current liabilities) x 50%

Is (A) equal to, or less than (B) for contractor?.... YES: then score **1.0**
.... NO : then score **zero**

TOTAL V1 SCORE CARRIED TO SUMMARY SHEET✍__________

V2 Age
Has the company been trading under the same company name within the construction sector for at least three years?
YES: then score **1.0**
NO : then score **zero**

TOTAL V2 SCORE CARRIED TO SUMMARY SHEET✍__________

V3 Image
Has the contractor supplied details of company membership of specialist trade associations? Award 0.5 for each membership (maximum score = 1) for which such membership is considered by the practitioner as complimenting this contractors' image. (**No membership = no score**).

V3a. Association 1. (score worth 0.5) ✎..CIOB chartered Co..........score;✍..................

V3b. Association 2. (score worth 0.5) ✎.Fed'... Master Builders.....score;✍..................

TOTAL V3 SCORE CARRIED TO SUMMARY SHEET✍__________

V4 Quality Control Policy
V4a. Does the company have appropriate Q.A. registration to B.S. 5750?
If answer is YES: score 1.0 and go to V5..score;✍................
If answer is NO: go to V4b

V4b. Does the company state that it intends to apply for appropriate Q.A. registration to BS 5750 within the next six months?
If answer is YES: score 0.5 and go to V5..score;✍................
If answer is NO: score zero

TOTAL V4 SCORE CARRIED TO SUMMARY SHEET✍__________

V5 Health & Safety Policy

V5a. Has the company formulated an internal safety policy in accordance with section 2(3) of HASWA 1974?.....................................(Yes = 0.1 No = zero)......score;✍................
V5b. If so are the company's' H&S objectives clearly laid down within.?..(Yes = 0.1 No = zero)......score;✍................
V5c. Does the document state that H&S are to be given the highest priority in all aspects of the works? ....(Yes = 0.1 No = zero)......score;✍................
V5d. Does the document describe duties of employees and management with regard to H&S?.......................................(Yes = 0.1 No = zero)......score;✍................

V5e. Does the company have a permanent
H&S Dept'?..(Yes = 0.1 No = zero)......score;✍.................
V5f. If so have its' representatives the power to
stop dangerous activities.?.................................(Yes = 0.1 No = zero)......score;✍.................
V5g. Do directly employed operatives receive H&S
awareness or first aid training?............................(Yes = 0.1 No = zero)......score;✍.................
V5h. Do site management receive H&S awareness
or first aid training?..(Yes = 0.1 No = zero)......score;✍.................
NOTE CHANGE IN SCORE VALUES;
V5j. Has the company been served with an improvement or prohibition
notice by the H.S.E. over the last 5 years.............(Yes = zero No = 0.1)......score;✍.................
V5k. Has the company had a fatal accident on any site under its' control
within the last 5 years......................................(Yes = 0.1 No = zero)......score;✍.................

TOTAL V5 SCORE CARRIED TO SUMMARY SHEET✍____________

V6. Litigation Tendency

What point on the following scale best represents the contractors litigation tendency? See comments relating to scale;

Point on scale.	*Comments.*
1.0.	The contractor is involved with multiple legal actions and observation of V20 indicates that the contractor has a strong claims consciousness.
5.0.	The contractor has a current/recent legal action with an employer and observation of both references under V20 indicates up to 50% cost overrun due to contractor claims.
10.0.	The contractor has NO current or recent legal actions and observation of V20 shows NO indication of cost overruns due to claims by the contractor.

1.........2.........3.........4.........5........6.........7........8.........9.........10

N.B. V6 score = point on scale divided by 10 ie., 8/10 = 0.8

TOTAL V6 SCORE CARRIED TO SUMMARY SHEET✍____________

V7; Ratio Analysis of Accounts

V7a.* Is current ratio score above critical limit of 1.0 ? ....(Yes; 0.167 No; zero)...✍.................
V7b. If answer is yes to V7a; has current ratio remained
stable or exhibited improvement over last 3 years figures?..(Yes; 0.167 No; zero)...✍.................

V7c.* Is NA/CL ratio score above critical limit of 1.0?.....(Yes; 0.167 No; zero)...✍.................
V7d. If answer is yes to V7c; has NA/CL ratio remained
stable or exhibited improvement over last 3 years figures?..(Yes; 0.167 No; zero)...✍.................

V7e.* Is interest cover above critical limit of 2.0?............(Yes; 0.167 No; zero)...✍.................

V7f. If answer is yes to V7e; has interest cover remained
stable or exhibited improvement over last 3 years figures?..(Yes; 0.167 No; zero)...✍.................
* *figures extracted from last full years trading accounts.*

TOTAL V7 SCORE CARRIED TO SUMMARY SHEET✍____________

V8; Bank reference

V8a. Has the company been with it's bank for a minimum 3 years?
If **No** score **zero** and go to next variable.
If **YES** go to **V8b.**

V8b. Mirror the contractor's Bank reference on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

This end of scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	This end of scale represents reference which instils confidence in the contractor

1.........2.........3.........4.........5........6.........7........8.........9.........10

N.B. V8 score = point on scale divided by 10 ie., 8/10 = 0.8

TOTAL V8 SCORE CARRIED TO SUMMARY SHEET✍____________

V9; Trade reference

V9a. Mirror the contractor's trade reference (Nr. 1) on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

This end of scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	This end of scale reflects excellent reference which instils confidence in the contractor

1.........2.........3.........4.........5........6.........7........8.........9.........10

V9b. Mirror the contractor's trade reference (Nr. 2) on the following scale where; 1 represents a poor reference and 10 represents an excellent reference.

This end of scale reflects poor reference, ie., one that does not instil confidence in the contractor company	Score of 5 reflects median response; neither excellent nor poor	This end of scale reflects excellent reference which instils confidence in the contractor

1.........2.........3.........4.........5........6.........7........8.........9.........10

Point on scale 9a✍.............Added to Point on scale 9b✍............Equals sub total✍...............
Sub total divided by 20 equals V9 score.

TOTAL V9 SCORE CARRIED TO SUMMARY SHEET✍____________

V10; Turnover History

V10a. Has the company shown turnover
contraction during the *period?...........................(Yes = zero No = 0.25)......score;✍.................
V10b. Has the company fallen below the critical
limit of 1.0 (current ratio) during the *period?......(Yes = zero No = 0.25)......score;✍.................
V10c. Has the company shown a decline in ROCE
on any previous year for the *period?.................(Yes = zero No = 0.25)......score;✍.................
V10d. Has the company held the critical limit of 50%
capital gearing during the *period?......................(Yes = zero No = 0.25)......score;✍.................
**period = last 3 trading years*

TOTAL V10 SCORE CARRIED TO SUMMARY SHEET✍____________

V11; Qualification of Company owners
Insert the variable (performance) scores as indicated, then add & divide by four to establish mean.

V11a. Turnover V10 score✍..................

V11b. Time V19 score✍..................

V11c. Cost V20 score✍..................

V11d. Quality V21 score✍..................

Sub total✍..................

Sub total divided by 4 = V11 score

TOTAL V11 SCORE CARRIED TO SUMMARY SHEET✍____________

V12; Qualification of Key Personnel
V12a. What %* of contractors' key personnel hold
a construction related Degree?.................................✍................% x 0.25 = ✍...............
V12b. What %* of contractors' key personnel are between
the age of 30 - 40 years old?......................................✍................% x 0.25 = ✍...............
V12c. What %* of the contractors' key personnel are corporate
members of the CIOB or the ICE?...........................✍................% x 0.25 = ✍...............
V12d. What %* of the contractors' key personnel have
overseas construction management experience?.........✍................% x 0.25 = ✍...............
* *expressed as a decimal.*

TOTAL V12 SCORE CARRIED TO SUMMARY SHEET✍____________

V13; Years with Co' Key personnel
V13. what percentage of management have been with the company since school leaving age and remained in the companys' employ for between 12 and 22 years?

Percentage expressed as a decimal equals variable score.

TOTAL V13 SCORE CARRIED TO SUMMARY SHEET✍____________

V14; Formal Training Regime
V14a. Does the company operate a formal training
regime (internal or external) to promote academic
qualification of it's managers?............................(Yes = 0.5 No = zero)......score;✍.................

V14b. Does the company operate an internal system of
inter-departmental experience to it's managers?.......(Yes = 0.5 No = zero)......score;✍.................

TOTAL V14 SCORE CARRIED TO SUMMARY SHEET✍____________

V15 Past experience - type of projects
V15. Has the contractor provided details (to the satisfaction of the practitioner) of a contract completed within the last 2 years for each of the work areas V15a - V15d described by the practitioner below?
Practitioners choice of work types (✎);

V15a. ✎..(Yes = 0.25 No = zero)......score;✍................
V15b. ✎..(Yes = 0.25 No = zero)......score;✍................
V15c. ✎..(Yes = 0.25 No = zero)......score;✍................
V15d. ✎..(Yes = 0.25 No = zero)......score;✍................

TOTAL V15 SCORE CARRIED TO SUMMARY SHEET✍____________

V16; Past experience - size of projects
V16a. Has the contractor experienced execution of a contract of similar size to the proposed project within the last 3 years?......... (Yes = 0.5 No = zero)......score;✍.................

V16b. Is the proposed project of a size most often undertaken by the contractor company? .... (Yes = 0.5 No = zero)......score;✍.................

TOTAL V16 SCORE CARRIED TO SUMMARY SHEET✍_____________

V17; National or Local catchment
Has the contractor supplied the address of one contract (min. contract period 2 months & executed within the last 2 years) which falls within any of the following regions?
(regions defined by the counties each encompasses).

V17a. **Scottish Region**.. (Yes; 0.1 No; zero)..✍................
V17b. **Northumbrian Region.** Northumberland, Tyne and Wear, Durham, Cleveland, North Yorkshire ....(Yes; 0.1 No; zero)..✍................
V17c. **North West Region.** Cumbria, Lancashire, Greater Manchester, Merseyside, Cheshire. ....(Yes; 0.1 No; zero)..✍................
V17d. **Yorkshire Region.** West Yorkshire, Humberside, South Yorkshire, Derbyshire. ....(Yes; 0.1 No; zero)..✍................
V17e. **Welsh region.** Gwynedd, Clwyd, Dyfed, Powys, West Glamorgan, Mid Glamorgan, South Glamorgan, Gwent..........(Yes; 0.1 No; zero)..✍................
V17f. **Severn Trent region.** Shropshire, Staffs, Notts, Leics, West Mids, Hereford & Worcestershire Warwickshire..............(Yes; 0.1 No; zero)..✍................
V17g. **Anglian Region.** Lincolnshire, Cambridgeshire, Norfolk, Northamptonshire, Suffolk, Bedfordshire, Essex. ....(Yes; 0.1 No; zero).. ✍................
V17h. **South West region.** Cornwall, Devon. ....(Yes; 0.1 No; zero)..✍................
V17j. **Wessex Region.** Gloucestershire, Avon, Wiltshire, Somerset, Dorset. ....(Yes; 0.1 No; zero)..✍................
V17k. **Thames & Southern region.** Oxfordshire, Bucks, Herts, Greater London, Berkshire, Kent, Surrey, Hamps, W. Sussex, E. Sussex. ....(Yes; 0.1 No; zero)..✍................

TOTAL V17 SCORE CARRIED TO SUMMARY SHEET✍_____________

V18; Failure to have completed a contract
Has the contractor ever failed to complete a contract (ie., achieve termination by performance) without having just reason, such as frustration or mutual agreement?...

If answer is No: score 1.0...score;✍................
If answer is Yes: score zero and go to V19

TOTAL V18 SCORE CARRIED TO SUMMARY SHEET✍_____________

V19; Overruns - time
V19a. *(reference No' 1).* From analysis of the information supplied by Referee Nr. 1 did the contractor complete the contract by the completion date?
IF YES THEN SCORE 0.5 AND GO TO V19c ....score;✍................
IF NO THEN SCORE ZERO AND GO TO V19b.
V19b. (reference No' 1 continued).
From analysis of the information supplied was the time overrun;
i) Entirely due to contractor's fault then score zero.
ii) Only partly due to contractor's fault then score 0.25............................score;✍................

iii) Not in any way attributable to contractor then score 0.5........................score;✍..................

V19c. *(reference No' 2).* From analysis of the information supplied by Referee Nr. 2 did the contractor complete the contract by the completion date?
IF YES THEN SCORE 0.5 then add total score for this variable...............score;✍..................
IF NO THEN SCORE ZERO AND GO TO V19d.

V19d. (reference No' 2 continued).
From analysis of the information supplied was the time overrun;
i) Entirely due to contractor's fault then score zero.
ii) Only partly due to contractor's fault then score 0.25..............................score;✍..................

iii) Not in any way attributable to contractor then score 0.5........................score;✍..................

V19 SCORE CARRIED TO SUMMARY SHEET✍____________

V20 Overruns - cost
V20a. Referee no' 1.
Did the contract overrun on cost ie., cost more than the original contract sum?
If answer is no then score the contractor 0.5 and go to V20b..................score;✍..................
If Answer is yes then;
what approx. percentage of the overrun was attributable to the contractor making contractual or common law claims? (a)..........%
Now deduct (a) (as a decimal) from 1.0 and multiply by 0.5 = ...score;✍..................

V20b. Referee no' 2.
Did the contract overrun on cost ie., cost more than the original contract sum?
If answer is no then score the contractor 0.5 and add up V20 total...........score;✍..................
If Answer is yes then;
what approx. percentage of the overrun was attributable to the contractor making contractual or common law claims? (b)..........%
Now deduct (b) (as a decimal) from 1.0 and multiply by 0.5 = ...score;✍..................

TOTAL V20 SCORE CARRIED TO SUMMARY SHEET✍____________

V21; Past performance - quality achieved
V21a. (Referee No' 1)
What was the rating given by referee number 1 regarding the quality of finished product?

This end of the scale represents a poor quality product in terms of workmanship.	A score of 5 represents acceptable quality workmanship	This end of the scale represents outstanding quality of workmanship

1.........2.........3.........4.........5........6.........7........8.........9.........10

V21b. (Referee No' 2)
What was the rating given by referee number 2 regarding the quality of finished product?

This end of the scale represents a poor quality product in terms of workmanship.	A score of 5 represents acceptable quality workmanship	This end of the scale represents outstanding quality of workmanship

1.........2.........3.........4.........5........6.........7........8.........9.........10

Point on scale 21a✍...........Added to Point on scale 21b✍...........Equals sub total✍..............

Sub total divided by 20 equals V21 score

TOTAL V21 SCORE CARRIED TO SUMMARY SHEET✍____________

Appendix G

P1 Summary analysis sheets

PREQUALIFICATION (P1) SUMMARY ANALYSIS SHEETS

FACTOR; Organisational structure

Variable		*Score*	x	*Weight*	=	*Rationalised Score*
V1	Size	....	x	0.501	=	....
V2	Age	....	x	0.435	=	....
V3	Image	....	x	0.408	=	....
V4	QC.	....	x	0.529	=	....
V5	H&S.	....	x	0.583	=	....
V6	Litigation	....	x	0.545	=	______

TOTALS; (a) 3.001 (b)..........

(b) divided by (a) = *Organisational structure* Factor Score = (c)...............

FACTOR; Financial Stability

Variable		*Score*	x	*Weight*	=	*Rationalised Score*
V7	Ratio	....	x	0.631	=	....
V8	Bank	....	x	0.669	=	....
V9	Creditors	....	x	0.634	=	....
V10	Turnover	....	x	0.667	=	______

TOTALS; (d) 2.601 (e)..........

(e) divided by (d) = *Financial stability* Factor Score = (f)...............

FACTOR; Management Resource

Variable		*Score*	x	*Weight*	=	*Rationalised Score*
V11	Owners	....	x	0.676	=	....
V12	Key persons	....	x	0.648	=	....
V13	Years d/o	....	x	0.695	=	....
V14	Training	....	x	0.814	=	______

TOTALS; (g) 2.833 (h)..........

(h) divided by (g) = *Management resource* Factor Score = (i)...............

FACTOR: Past Experience

Variable	*Score*	x	*Weight*	=	*Rationalised Score*
V15 Type	....	x	**0.735**	=	....
V16 Size	....	x	**0.851**	=	....
V17 Catchment	....	x	0.748	=	________

TOTALS; (j) 2.334 (k)..........

(k) divided by (j) = *Past Experience* Factor Score = (m)...............

FACTOR: Past Performance

Variable	*Score*	x	*Weight*	=	*Rationalised Score*
V18 Failure	....	x	**0.679**	=	....
V19 Time	....	x	**0.541**	=	....
V20 Cost	....	x	**0.576**	=	....
V21 Quality	....	x	0.667	=	________

TOTALS; (n) 2.463 (o)..........

(o) divided by (n) = Performance Factor Score = (p)...............

PREQUALIFICATION (P1) FINAL CALCULATION

Factor	*Max poss. factor score*	*Factor scores*
Organisational structure	1.0	(c).............
Financial stability	1.0	(f).............
Management resource	1.0	(i).............
Past experience	1.0	(m).............
Past performance	1.0	(p)________

TOTALS; (q) 5.0 (r)..............

(r) divided by (q) = P1 score = ...which x 100 may be expressed as..............% potential

Appendix H

P2 Analysis sheets

TENDER EVALUATION (P2) ANALYSIS SHEETS

NB.

= descriptive insertion required by practitioner.
= numeric insertion required by practitioner

V22; Experience within the geographic area of the project
Has the contractor executed a contract of minimum duration 6 months during

the last 3 years, within the area as defined by a 25 mile radius from the proposed project?

If answer is YES: score 1.0 and go to V23..score;................
If answer is NO: score zero and go to V23

TOTAL V22 SCORE CARRIED TO SUMMARY SHEET___________

V23. Experience of similar specific work elements
Has the contractor provided brief details of a relevant contract (executed within the last 2 years) to show experience in each of the specific work elements V23a - V23k (as defined by the practitioner)?

V23a. ....(Yes; 0.1 No; zero)......score;................
V23b. ....(Yes; 0.1 No; zero)......score;................
V23c ....(Yes; 0.1 No; zero)......score;................
V23d. ....(Yes; 0.1 No; zero)......score;................
V23e. ....(Yes; 0.1 No; zero)......score;................
V23f. ....(Yes; 0.1 No; zero)......score;................
V23g. ....(Yes; 0.1 No; zero)......score;................
V23h. ....(Yes; 0.1 No; zero)......score;................
V23j. ....(Yes; 0.1 No; zero)......score;................
V23k. ....(Yes; 0.1 No; zero)......score;................

TOTAL V23 SCORE CARRIED TO SUMMARY SHEET___________

V24; Plant acquisition policy
V24a. Does the contractor exhibit a realistic perception of the major
plant requirements for the proposed project?.............(Yes; 0.5 No; zero)......score;................
V24b. Which of the following statements best describes the contractors' plant
acquisition policy?
i. Approx. 50% own/50% hire (score 0.5)..score;................

ii. All own or all hire (score 0.25)..score;................

TOTAL V24 SCORE CARRIED TO SUMMARY SHEET___________

V25; Key persons available for project

V25a Number of **senior** managers proposed for project by contractor (✍..........)
divided by the desired number of managers (✍...........) = coefficient: ✍..........
(where proposed >desired co-efficient = 1.0) ....co-efficient x 0.5 = score;....✍.................

V25b Number of **first line** managers proposed for project by contractor (✍..........)
divided by the desired number of managers (✍...........) = coefficient: ✍..........
(where proposed >desired co-efficient = 1.0) ....co-efficient x 0.5 = score;....✍.................

TOTAL V25 SCORE CARRIED TO SUMMARY SHEET✍____________

V26; 'Key persons available' refers to the permanent on-site management structure outlined by the contractor in V25 as being committed to the proposed project.

V26a. What percentage* of key persons available hold a construction related degree?...✍.............. % x 0.25 = ...✍.....................
V26b. What percentage* of key persons available are between the age of 30 - 40 yrs?...✍.............. % x 0.25 = ...✍.....................
V26c. What percentage* of key persons available are corporate members of the CIOB or the ICE ?..........................✍.............. % x 0.25 = ...✍.....................
V26d. What percentage* of key persons available have overseas construction experience ?..........................✍.............. % x 0.25 = ...✍.....................
** expressed as a decimal*

TOTAL V26 SCORE CARRIED TO SUMMARY SHEET✍____________

V27; Current workload capacity

Approximate value of contractors' maximum financial outlay (MFO) may be determined

via the formula = $\sum_{i=1}^{n} 2(Vi/Di)$ where;

V = contract values (£),
D = contract durations (month) and
n = all contracts (including that being tendered for) that are being undertaken/will be undertaken during the life of the project being tendered for.

Unmodified maximum financial capacity (unmodified MFC) can be determined from V1.
V27a. Does the contractors MFO (as calculated above)

exceed the firms' MFC?................................. (Yes = zero No = 1.0.)......score;✍.................

TOTAL V27 SCORE CARRIED TO SUMMARY SHEET✍____________

V28. Previous relationship
Has the client had a previous working relationship with this contractor? :-
IF NO: then score zero and go to V29.
IF YES THEN;
How does the client rate that previous relationship on the following scale;

This end of scale represents a poor previous relationship	This end of scale represents a good previous relationship

1.........2.........3.........4.........5........6.........7........8.........9.........10

(Variable score = rating divided by 10 ie., 8/10 = 0.8)

TOTAL V28 SCORE CARRIED TO SUMMARY SHEET____________

V29; Home office location in relation to project
Does the proposed project fall geographically within a 25 mile radius of the contractors' nearest regional/head office?..(Yes = 1.0 No = zero)......score;.................

TOTAL V29 SCORE CARRIED TO SUMMARY SHEET____________

The above completes the first stage of P2 analysis

Carry forward V scores to summary sheet for final computation

Appendix I

P2 Summary analysis sheet

TENDER EVALUATION (P2) SUMMARY ANALYSIS SHEET

FACTOR: Project Specific

Variable	*Weight*	x	*Utility*	x	*Score*	=	*Rationalised Score*
V22 Geographic	0.409	x	....	x	....	=	....
V23 Experience	0.564	x	....	x	....	=	....
V24 Plant	0.486	x	....	x	....	=	....
V25 Key persns	0.547	x	....	x	....	=	....
V26 Qual -:-	0.673	x	....	x	....	=	....
TOTALS	(s) 2.679						(t) ________

(t) divided by (s) = *Project specific* Factor Score = (u)................

FACTOR: Other Specific

Variable	*Weight*	x	*Utility*	=	x *Score*	=	*Rationalised Score*
V27 Workload	0.862	x	....		x	=	....
V28 Relation'	0.651	x	....		x	=	....
V29 Office loc'	0.642	x	....		x	=	....
TOTALS (v)	2.155						(w) ________

(w) divided by (v) = Other Specific Factor Score = (x)...............

TENDER EVALUATION (P2) FINAL CALCULATION

Factor	Max poss. factor score	Factor scores
Project Specific	1.0	(u).............
Other Specific	1.0	(x).............
TOTALS;	(y) 2.0	(z)__________

(z) divided by (y) = P2 score = ...which x 100 may be expressed as..............% potential

Appendix J

Prequalification questionnaire

Prequalification Questionnaire *page 1 of 2*

Note to contractor. Please complete questions 1 to 16 as comprehensively as possible. Enter "not applicable" or "none" etc. where necessary -please do not leave "blank" spaces. All information provided will be treated in the strictest of confidence.

Contractors name and address;..

....

Q1. Please supply a copy of your last 3 years trading accounts (inc. balance sheet & P&L account). Copies enclosed? (Y/N)...

Q2. Has your company traded under the same name, within the construction sector, over the last 3 years? (Y/N)..

Q3. Indicate two trade organisations to which your company belongs (eg' C.I.O.B. Chartered Company Scheme).
a)..
b)..

Q4. Is your organisation B.S. 5750 registered? (Y/N)..........................If not, do you intend to apply for registration within the next 6 months? (Y/N)..................................

Q5. Please provide a copy of your internal safety policy -copy enclosed? (Y/N)................
Do you have a permanent Health and Safety department ? (Y/N)..................
If so, does it's representatives have the power to stop dangerous activities?(Y/N)..............
Do your directly employed operatives receive H&S awareness or first aid training? (Y/N)...........
Do site management receive H&S awareness or first aid training? (Y/N)..................
Has your Company been served an improvement or prohibition notice by the Health & Safety Executive within the last 5 years? (Y/N)...................
Has your company experienced a fatal accident on any site under its control within the last 5 years (Y/N)............

Q6. Please list on the reverse of this sheet any litigation your company is presently involved with. Please indicate whether company is Plaintiff or Defendant and the nature of the dispute. Litigation listed overleaf? (Y/N) or (none) ....

Q7. How many years has your company been with it's current bankers?...............years.
Please supply a copy of a current bank reference. Copy enclosed? (Y/N)........................

Q8. Please provide copies of two references, from suppliers with whom you have traded for at least 3 years. References included (Y/N) or (none)..............

Q9. What percentage of your site managers hold a construction related degree? ....%
What percentage of your site managers are between 30-40 years old? ....%

Prequalification Questionnaire *page 2 of 2*

Q9 cont..What percentage of your site managers are corporate members of either the C.I.O.B. or the I.C.E.?..............%.

What percentage of your site managers have overseas construction experience?..............%

Q10.What percentage of *all* your managers have been with you since leaving school/education and remained in your employ for at least 12 years? ....%

Q11.Do you operate a formal training regime (internal or external) to promote academic qualification of your management? (Y/N)..........................

Do you operate an internal system of inter-departmental training experience to your managers? (Y/N).................

Q12.Indicate how many of the following types of work your company has experienced within the last two years? (please tick if applicable).

1...2...

3...4...

Q13.What is the value of the largest contract undertaken by your company within the last three years? £.................

Please indicate the contract value range most often undertaken by your company :-

From £K..............to £K................

Q14.Have you executed a contract (min. contract period 2 months and within the last 2 years) which falls within each/any of the following regions? Please indicate yes or no for each.

Scotland..Yes/no
Northumbrian Region [Northumberland,Tyne and Wear, Durham, Cleveland, North Yorkshire]......Yes/no
North West Region [Cumbria, Lancashire, Greater Manchester, Merseyside, Cheshire] ....Yes/no
Yorkshire Region [West Yorkshire, Humberside, South Yorkshire,Derbyshire]........................Yes/no
Welsh region[Gwynedd, Clwyd, Dyfed, Powys, W. Glamorgan, Mid Glamorgan, S. Glamorgan, Gwent] .Yes/no
Severn Trent region [Shrops, Staffs, Notts, Leics, West Mids, Hereford & Worcs Warks]............Yes/no
Anglian Region. [Lincs, Cambs, Norfolk, Northamptonshire, Suffolk, Bedfordshire, Essex]..........Yes/no
South West region. [Cornwall, Devon].. Yes/no
Wessex region [Gloucestershire, Avon, Wiltshire, Somerset, Dorset]. ....Yes/no
Thames/Southern [Oxfordshire, Bucks, Herts, London, Berks, Kent, Surrey, Hamps, Sussex] .... Yes/no

Q15.Has your company ever failed to complete a contract ?.......(Y/N) ....
If yes, why was that?...

Q16. Would you please supply details of two previous clients whom we may approach for a reference. Referees listed overleaf? (Y/N)...

Appendix K

Tenderer evaluation questionnaire

Tenderer evaluation questionnaire *page 1 of 2*

Note to contractor. Please complete questions 1 to 6 as comprehensively as possible
Enter "not applicable" or "none" etc. where necessary
All information provided will be treated in the strictest of confidence

Contractors name and address;..

....

Q1. Has your company previously [last 3 years] executed a contract [min. duration 6 months] within an area defined by a 25 mile radius from the proposed project? (Y/N)..................

Q2. Indicate whether you have executed any of the following types of work, within the last two years;

a.✎.. (Y/N).......................
b.✎.. (Y/N).......................
c ✎.. (Y/N).......................
d.✎.. (Y/N).......................
e.✎.. (Y/N).......................
f.✎.. (Y/N).......................
g.✎.. (Y/N).......................
h.✎.. (Y/N).......................
j.✎.. (Y/N)....................
k ✎.. (Y/N)......................

Q3. Briefly indicate what you perceive as the major plant requirements for the proposed project...

....

....

Which of the following statements best describes your plant acquisition policy? (tick)

a) Approx. 50% own/50% hire................
b) All own or all hire ....

Q4. What number of **senior** managers (ie upwards of site manager) do you intend to make available for the proposed project..............................

What number of **first line** managers (ie site foremen, chargehands etc.) do you intend to make available for the proposed project? ....

Tenderer evaluation questionnaire *page 2 of 2*

Please indicate what percentage of the managers above (ie all those who are to be actively involved with the project);

- hold a construction related degree?..
- are between the age of 30 - 40 yrs?..
- are corporate members of the CIOB or the ICE ?........................
- have overseas construction experience ?..................................

Q5. List all contracts currently being undertaken AND to be commenced by your company during the next ✎..................................months;

Contract duration [months]......................Value [£]............................
Contract duration [months]......................Value [£]............................
Contract duration [months]......................Value [£]............................
Contract duration [months]......................Value [£]............................
Contract duration [months]......................Value [£]............................

(continue overleaf if necessary)

Q6. Please give the address of your companys' **nearest** (head/regional) office, in relation to the proposed project;

....
....
....
....
....
....

Appendix L

Client questionnaire

Client questionnaire *page 1 of 1*

Project...Date.......................

Q1. Ideally, how many senior managers (ie., site manager and upwards) would you like the successful contractor to make available for your project?........................

Q2. Ideally, how many first line managers (ie., foremen, chargehands etc.) would you like the successful contractor to make available for your project?........................

Q3. For *each* contractor tendering please indicate ion a scale of 1 to 10, how you rate your previous relationship with them, where 1 = poor relationship and 10 = good relationship.

Contractor	Score (1 - 10)	No previous relationship (tick)
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....
....	....	....

Q4. What do you perceive as the main plant requirements for the project?...

....

Q5. In the context of your **proposed project**, how important do you feel are the following contractor attributes? Please score each attribute on a scale of 1 to 10
where; 1 = No importance, 5 = some importance and 10 = critically important.

5.1. "The contractor should have previous work experience in the geographic area of our project" **Score**..............

5.2. "The contractor should have previous work experience of a nature similar to that which he will encounter on our project" **Score**..............

5.3. "The success of our project will depend upon the plant resource available to the contractor" **Score**..............

5.4. "The success of our project will depend upon the *number* of key persons (management) available to the contractor" **Score**..............

5.5. "The success of our project will depend upon the *qualification* of the key persons available to the contractor". **Score**..............

5.6. "The success of our project will depend upon the contractors workload at the time he is executing our project". **Score**..............

5.7. "The success of our project will depend upon any previous working relationship that we have had with the contractor". **Score**..............

5.8. "The success of our project will depend upon the location of the contractors nearest head/regional office - in relation to our project". **Score**..............

Appendix M

Blank computer spreadsheets

PREQUALIFICATION (P1) ANALYSIS;

Factor : Organisational	Structure.		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V1: Size		**0.501**	0.000
V2: Age		**0.435**	0.000
V3: Image		**0.408**	0.000
V4: Quality Control policy		**0.529**	0.000
V5: Health & Safety policy		**0.583**	0.000
V6: Litigation Tendency		**0.545**	0.000
	TOTALS:	3.001	0.000
	Factor score	**is:**	0.000

Factor : Financial	Stability		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V7: Ratio anaysis		**0.631**	0.000
V8: Banf reference		**0.669**	0.000
V9: Creditors reference		**0.634**	0.000
V10: Turnover history		**0.667**	0.000
	TOTALS:	2.601	0.000
	Factor score	**is:**	0.000

Factor : Management	Resource		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V11: Qualification - owners		**0.676**	0.000
V12: Ditto - key persons		**0.648**	0.000
V13: Key persns yrs with Co		**0.695**	0.000
V14: Training regime		**0.814**	0.000
	TOTALS:	2.833	0.000
	Factor score	**is:**	0.000

Factor : Past experience			
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V15: type proj' completed		**0.735**	0.000
V16: Size proj' completed		**0.851**	0.000
V17: Area of catchment		**0.748**	0.000
	TOTALS:	2.334	0.000
	Factor score	**is:**	0.000

Factor : Past	performance		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V18: Fail' to complete cntrct		**0.679**	0.000
V19: Time overruns		**0.541**	0.000
V20: Cost overruns		**0.576**	0.000
V21: Quality record		**0.667**	0.000
	TOTALS:	2.463	0.000
	Factor score	**is:**	0.000

Z1 score is:	0.000
Z1 max is:	13.232
P1 score is:	**0.000**
Which may be expressed as %	0.000

EVALUATION (P2) ANALYSIS;

Factor : Project specific				
Variable (V)	*Contractors 'V' Score*	*Weight*	*Utility*	*Rationalised Score*
V22: Geographic experience		**0.409**	1.000	0.000
V23: Experience- similar const'		**0.564**	1.000	0.000
V24: Plant resource		**0.486**	0.900	0.000
V25: Key persons available		**0.547**	1.000	0.000
V26: Ditto - qualification		**0.673**	1.000	0.000
	TOTALS:	2.679		0.000
	Factor score	**is:**		0.000

Factor : Other specific				
Variable (V)	*Contractors 'V' Score*	*Weight*	*Utility*	*Rationalised Score*
V27: Current workload		**0.862**	1.000	0.000
V28: Prior relationship		**0.651**	0.700	0.000
V29: Home office location		**0.642**	0.600	0.000
	TOTALS:	2.155		0.000
	Factor score	**is:**		0.000

Z2 score is:	0.000
Z2 Max is:	4.834
P2 score is:	**0.000**
Which may be expressed as %:	0.000

FINAL SELECTION (P3) ANALYSIS;

Bid component;	
Lowest bid:	
This contractors bid:	
Bid score:	#DIV/0!
P2 score brough forward:	0.000
P3 score is:	**#DIV/0!**

Appendix N

Spreadsheets for Cr_1

PREQUALIFICATION (P1) ANALYSIS;

Factor : Organisational	**Structure.**		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V1: Size	1.000	0.501	0.501
V2: Age	1.000	0.435	0.435
V3: Image	1.000	0.408	0.408
V4: Quality Control policy	1.000	0.529	0.529
V5: Health & Safety policy	0.700	0.583	0.408
V6: Litigation Tendency	0.700	0.545	0.382
	TOTALS:	3.001	2.663
	Factor score	**is:**	**0.887**

Factor : Financial	**Stability**		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V7: Ratio anaysis	0.670	0.631	0.423
V8: Banf reference	0.800	0.669	0.535
V9: Creditors reference	0.850	0.634	0.539
V10: Turnover history	0.750	0.667	0.500
	TOTALS:	2.601	1.997
	Factor score	**is:**	**0.768**

Factor : Management	**Resource**		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V11: Qualification - owners	0.785	0.676	0.531
V12: Ditto - key persons	0.650	0.648	0.421
V13: Key persns yrs with Co	0.800	0.695	0.556
V14: Training regime	1.000	0.814	0.814
	TOTALS:	2.833	2.322
	Factor score	**is:**	**0.820**

Factor : Past experience			
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V15: type proj' completed	0.750	0.735	0.551
V16: Size proj' completed	1.000	0.851	0.851
V17: Area of catchment	0.600	0.748	0.449
	TOTALS:	2.334	1.851
	Factor score	**is:**	**0.793**

Factor : Past	**performance**		
Variable (V)	*Contractors 'V' Score*	*Weight*	*Rationalised Score*
V18: Fail' to complete cntrct	1.000	0.679	0.679
V19: Time overruns	0.750	0.541	0.406
V20: Cost overruns	0.800	0.576	0.461
V21: Quality record	0.850	0.667	0.567
	TOTALS:	2.463	2.113
	Factor score	**is:**	**0.858**

Z1 score is:	10.945
Z1 max is:	13.232
P1 score is:	**0.827**
Which may be expressed as %	82.7

	J	K	L	M	N	O
2	**EVALUATION**	**(P2) ANALYSIS;**				
3						
4						
5	**Factor : Project specific**					
6	*Variable (V)*	*Contractors 'V' Score*	*Weight*	*Utility*	*Rationalised Score*	
7	V22: Geographic experience	1.000	0.409	1.000	0.409	
8	V23: Experience- similar const	0.800	0.564	1.000	0.451	
9	V24: Plant resource	0.750	0.486	0.900	0.328	
10	V25: Key persons available	0.830	0.547	1.000	0.454	
11	V26: Ditto - qualification	0.800	0.673	1.000	0.538	
12		TOTALS:	2.679		2.181	
13						
14		Factor score	is:		0.814	
15						
16						
17						
18						
19	**Factor : Other specific**					
20	*Variable (V)*	*Contractors 'V' Score*	*Weight*	*Utility*	*Rationalised Score*	
21	V27: Current workload	1.000	0.862	1.000	0.862	
22	V28: Prior relationship	0.600	0.651	0.700	0.273	
23	V29: Home office location	1.000	0.642	0.600	0.385	
24		TOTALS:	2.155		1.521	
25						
26		Factor score	is:		0.706	
27						
28						
29						
30	**Z2 score is:**	3.701				
31	**Z2 Max is:**	4.834				
32	**P2 score is:**	**0.766**				
33	Which may be expressed as %:	76.57				
34						
35						
36						
37						
38	**FINAL SELECTION**	**(P3) ANALYSIS;**				
39						
40						
41	Bid component;					
42	Lowest bid:	475.000				
43	This contractors bid:	486.000				
44	Bid score:	0.977				
45	P2 score brough forward:	0.766				
46	**P3 score is:**	**0.893**				
47						
48						
49						
50						

Appendix P

Contractor survey questionnaire

UNIVERSITY OF WOLVERHAMPTON
School of Construction
Tendering and contractual procedures: survey of contractor opinion

Tendering and contractual issues have received much attention of late, particularly, by the most recent Government / Industry review of the construction sector headed by Sir. Michael Latham. This survey seeks contractor's views with regard tendering / contractor selection / contractual issues.

Where a box is provided ie., ☐ please tick the selection of your choice. Where a scale is provided please encircle a number on the scale to indicate your response eg., 1 2 3 4 5. A line is provided ie., ________ for you to indicate "other" where appropriate. To facilitate full analysis of opinion, please answer all questions.

This questionnaire is purely for the purposes of academic research. All responses will be treated in strict confidence

---

Part A: General information for data classification purposes;

1. How would you describe your company's prime activity;

Contractor ☐ Speculative developer ☐ Contractor / developer ☐ Other (specify)________________

2. Where does your company operate: Within a region ☐ National ☐ International ☐

3. What was your company's' turnover last year: £________________

4. Please indicate the approximate percentage of each work type that your company normally undertakes;

Contract work private sector	________%
Contract work public sector	________%
Speculative development	________%
Other (specify)________________	________%
	100%

5. What percentage of contracts tendered for are awarded to your company? ________________%

Part B: Tendering and contractual arrangements;

6. Indicate approximate percentages of the following that your company take part in, to obtain contracts;

Negotiation	________%
Open competition	________%
Select competition	________%
2 stage tendering	________%
Serial / continuity	________%
Other (specify)________________	________%
	100%

7. Circle a number on the scale to indicate your preference for each of the following where: 1=not preferred 3 = undecided and 5= much preferred;

	not preferred		*undecided*		*much preferred*
Negotiation	1	2	3	4	5
Open competition	1	2	3	4	5
Select competition	1	2	3	4	5
2 stage tendering	1	2	3	4	5
Serial / continuity	1	2	3	4	5
Other (specify)________________	1	2	3	4	5

8. On what documents do you normally tender -please indicate approximate percentages;

BOQ's & drawings	______%
Drawings & Specification	______%
Approximate BOQ's	______%
Other (specify)______	______%
	100%

9. Indicate your preference of tender documents on the following scale, where 1 = not preferred 3 = undecided and 5 = much preferred;

	not preferred		*undecided*		*much preferred*
BOQ's & drawings	1	2	3	4	5
Drawings & specification	1	2	3	4	5
Approximate BOQ's	1	2	3	4	5
Other (specify)______	1	2	3	4	5

10. Indicate the approximate percentages of contractual arrangements under which you normally operate;

Traditional (JCT)	______%
Management	______%
Design & Build	______%
Other (specify)______	______%
	100%

11. Indicate your preference of contractual arrangement on the following scale where 1 = not preferred 3 = undecided and 5 = much preferred;

	not preferred		*undecided*		*much preferred*
Traditional (JCT)	1	2	3	4	5
Management	1	2	3	4	5
Design & Build	1	2	3	4	5
Other (specify)______	1	2	3	4	5

Part C: The Latham Review;

12. Below are a list of features connected with tendering and contractual issues, recently advocated by the Latham Review. Please indicate your level of agreement with each statement where: 1 = strongly disagree, 3 = undecided and 5 = strongly agree;

	strongly disagree		*undecided*		*strongly agree*
a). Dept. of Environment (DOE) should prepare a prequalification questionnaire for use by all contractors desirous of public sector work.	1	2	3	4	5
b) Public sector should cease devising their own prequalification questionnaires	1	2	3	4	5
c) The new questionnaires should be issued and received only by the DOE who would maintain a 'central' list of 'approved' contractors	1	2	3	4	5
d) Only such 'approved' contractors should be invited to tender for Government commissioned work	1	2	3	4	5
e) There is no need for Local authorities, housing associations, educational establishments, NHS trusts, or health authorities to maintain their own list of contractors	1	2	3	4	5
f) Local authorities, housing associations, educational establishments, NHS trusts, etc. should only use a 'National' prequalification system not their own system	1	2	3	4	5
g) A national system should also be a quality register related to contractor performance	1	2	3	4	5
h) A charge should be levied on 'approved' firms joining the central register	1	2	3	4	5
i) Sub-contractors hoping for public sector work should also be registered in a similar manner to that described above	1	2	3	4	5
j) Main contractors should as a condition of contract, only employ such registered sub-contract firms	1	2	3	4	5

Part D: Scope for changes to current selection practice;

13. Below are a list of features associated with a contractor selection method being developed at the University of Wolverhampton. Please indicate how important you consider each of these features on the scale where: 1 = not important, 3 = undecided and 5 = very important.

		Not important		*undecided*		*Very important*
a)	'Select' 'approved' or 'standing' lists are not used	1	2	3	4	5
b)	All contractors desirous to tender are prequalified per project	1	2	3	4	5
c)	All contractors invited to tender are further evaluated, in view of project specific criteria ie., their potential to satisfactorily execute project being tendered for	1	2	3	4	5
d)	The method uses a standard set of selection criteria at all times	1	2	3	4	5
e)	The selection criteria could be made known to contractors	1	2	3	4	5
f)	The method could offer feedback to 'unsuccessful' contractors	1	2	3	4	5
g)	A 'score' is computed for each contractor evaluated	1	2	3	4	5
h)	The above score could be made available to all contractors evaluated	1	2	3	4	5
j)	If adopted by the industry as a whole, a 'standard' procedure would prevail	1	2	3	4	5

14. Finally, do you wish to make any comment about current tendering procedures and contractual arrangements in the UK construction industry?

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If you would be prepared to discuss this topic with the author of this questionnaire, please offer your name and telephone number: ______________________________

Thank you for taking the time to complete this questionnaire.

Please return in the self addressed, post paid envelope provided to;

Gary D. Holt
School of Construction
University of Wolverhampton
West Midlands WV1 1SB

If you would like a summary of the survey findings, please enter recipient name and company address below;

____

____

Appendix Q

Contractor survey

-comments made by respondents

COMMENTS MADE BY RESPONDENTS

"It is difficult to get onto tender lists but once on a list we receive repeat enquiries.

"We have made the decision not to enter into competition in the present market. Companies are still tendering at up to 10% below cost to achieve work -this is suicidal. We are not prepared to compromise our standards and would rather obtain work via recommendation / negotiation.

"Design and build tendering procedures tend to vary in the quality of information available -from detailed client requirements to vague outlines.

"Tendering periods are often too short and the quality of documentation poor.

"There is a great need for standardisation including shorter and more precise contracts. Alteration of standard contracts should be discouraged. More attention should be given to conciliatory procedures.

"All government departments should place all work to private professional practices and contractors, on a regional basis. Direct Labour Organisations should be abandoned.

"There is too much onus on the contractor these days compared with 10 - 20 years ago. There are not enough bills of quantity used. There is too much risk associated with design and build contracts with little reward.

"Any selection method that would eliminate 'rogue' contractors is welcome.

"Standard tender selection methods often dictate to contractors rather than placating client need. Any system should be adaptable to suit individual projects and contractors. Often, in attempting to be 'fair' the system demands a lot of wasted time and effort.

"Current procedures are a mess and often badly managed. Lengthy prequalification documents for work under £400K waste everyone's time.

"Present methods use poor documentation and cause us problems.

"Quality of tender documents / information has declined significantly as a result of fee bidding. Clients always want the cheapest job and they get what they pay for!

"Currently too much time, effort and resource is expended by contractors seeking to procure work when more often than not final selection is made on price. Select lists should have a common format and for public work a central register should suffice. To engender confidence and trust between clients / contractors the process of selection and execution should be simplified, this is one way that costs can be driven down.

"The current procedures especially on design & build are extremely wasteful eg., four scheme designs, 4 sets of `BOQ's etc.

"Tender lists are too large. Risks should be placed with the party best able to deal with them.

"Current procedures place unreasonable pressures on contractors that are then carried on to the contract, consideration should be given to omitting the lowest tender and accepting second lowest. This would ease cut-throat tendering, allow for correct price tenders and ease contract claims.

"Local authority lists are often decided on political systems to benefit DLO's. The lists try to eliminate competitive contractors to make life easier for DLO's.

"Tender documentation is getting poorer, particularly plan & specification. Value of plan & specification tenders are higher -used to be up to £200,000 but now up to £700,000. Tender periods are getting shorter.

"Design & build tenders from Housing Associations are appalling -they usually invite more than the recommended number of tenderers. Site investigation and engineering designs are carried out by each contractor tendering which means sometimes six to eight times this cost. Many schemes don't have planning permission and some sites do not have the licence to build.

"There is an increasing tendency to invite tenders on plan & specification with as many as six to eight contractors. The quality of tender information is leaning toward greater risk on the contractor.